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BRAZILIAN ICHNEUMONIDÆ AND BRACONIDÆ OBTAINED BY THE STANFORD EXPEDITION.*

STANFORD EXPEDITION TO BRAZIL, 1911.
J. C. BRANNER, Director.

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All of the species considered in the present paper were obtained by an expedition undertaken by a number of naturalists from Stanford University. The party was led by Prof. J. C. Branner, and during a sojourn of several months, they visited a number of regions where little or no entomological collecting had previously been done. Mr. William M. Mann accompanied the expedition as entomologist, and as might be expected, many of the Parasitic Hymenoptera obtained prove to be undescribed.

I have not been able to deal with every species, for example, members of the genus Ophion, as it is quite impossible to recognize with certainty some of the forms described by Fabricius and other of the earlier writers.

A number of genera are here recorded from South America for the first time, and it has been found necessary to propose new genera in several instances for the Brazilian forms.

*Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 55.

Family ICHNEUMONIDÆ

Subfamily ICHNEUMONINÆ

Cryptopyge obtusa Kriechbaumer.

Berliner Entom. Zeitng., Vol. 43, p. 128. 1898.

There is a female of this species from the Rio Madiera (Madeira-Mamoré, R. R. camp 43).

Kriechbaumer attributes the species to South America with some doubt, but there can be no question regarding the identity of the present female. The antennæ, broken in Kriechbaumer's type, are enlarged from the twelfth joint.

Tetragonochora cetepurange sp. nov.

Male. Length 12.5 mm. Orange yellow, marked with black, the head, pleuræ and venter paler yellow. The black markings are as follows; head above the posterior foramen over the vertex nearly to the antennæ, the yellow extending farther upward on the sides of the front and the orbits where it attains the level of the lower ocellus, on the temples it descends lower, next to the eye, passing the level of the lower ocellus; antennæ; mesonotum on its posterior two-thirds; scutellum with a large spot medially that attains the base, but not the sides nor apex; abdominal petiole at the middle with a V-shaped spot; second, third and fourth abdominal segments each with a broad band that does not attain the sides; fifth segment, except the sides; sixth and seventh and eight segments entirely; posterior knees; posterior tarsi, and apical three joints of middle tarsi. Fore wings deep fulvous on the basal half, then nearly hyaline to the black apex which begins just before the middle of the second section of the radius. Hind wings pale yellowish with blackened tips. Wing veins fulvous before the stigma, piceous beyond; stigma fuscous. Antennæ beyond the middle with the joints dentate below. Head deeply excavated above the antennæ, just below the median ocellus with a transverse tubercular elevation; face on each side with a shallow depression, separated by a median raised portion; clypeus not separated, but with a small, very deep circular impression on each side above, its lower margin straight medially and produced into an angular tooth at each lateral angle. Mandibles with two subequal black teeth. Head entirely smooth and shining, margined behind. Mesonotum minutely punctulate, the middle lobe prominent in front. Scutellum sparsely punctate anteriorly, longitudinally striated on its posterior half; margined laterally and separated from the mesonotum by a deep, longitudinally striated depression. Metathorax punctate; the superomedian area defined anteriorly, but open behind; pleural carina complete to the base of the hind coxa. Abdominal petiole aciculate, its spiracles almost linear, near the tip; second segment aciculate medially and deeply punctate near the lateral margins; third segment with same sculpture, but much finer; remainder of abdomen very finely and sparsely punctulate. Wings with four sided, obliquely trapezoidal areolet. Submedian cell longer than the median by nearly

one-third the length of the basal nervure; discoidal vein arising at the lower third of the second discoidal cell; transverse median vein of hind wing broken almost at its extreme apex.

One male collected by Mann and Baker, at Kete Purange, near Manaos, Brazil.

This species is related to *I. annulata* Brullé from Guiana from which it differs in structure and slightly in color, although of quite similar color-pattern.

Subfamily CRYPTINÆ

Megaplectes branneri sp. nov.

Male. Length 16 mm. Ferruginous, the head and anterior part of the thorax black with yellowish white markings. The entire face and mouthparts are pale, as well as the inner orbits above the antennæ, those behind the upper part of the eye, and the cheeks. The prothorax is also lined above and below, the mesopleura at its anterior upper angle, the scutellum on its sides and behind, and the whole postscutellum and the tegulæ pale. Antennæ black, with broad whitish annulus near the apex. Legs pale yellow, the four posterior ones ferruginous to the tips of the femora. Fore femora along the lower edge, last two joints of fore tarsi, a streak apically below on the middle femur, the middle tibial spurs, last three tarsal joints; second trochanter of hind leg, tip of femur, inner side of tibia and its spurs piceous or black. Wings pale ferruginous, stigma and veins black. Head smooth, impunctate, face with a longitudinal depression each side of the median line terminated below by the large clypeal foveæ; anterior edge of clypeus truncate, very faintly produced at the middle. Antennæ about as long as the body, slender and tapering, the first joint of the flagellum four times as long as thick, following decreasing in length; those toward the middle of the flagellum twice as long as thick; all except a few basal joints slightly nodosely thickened near their tips as in certain genera of Joppini although not so distinctly. Maxillary palpi with the second joint triangularly enlarged, the fifth joint very slender, nearly as long as the two preceding; labial palpi simple. Mesonotum finely, confluently punctate, without parapsidal furrows; scutellum more coarsely and sparsely punctate. Metathorax armed with a pair of unusually large and stout erect lateral spines; incompletely areolated; pleural carinæ complete, very strongly and evenly curved; basal pleural areas complete, sparsely punctate; basal median one smooth medially; hexagonal in position, but open behind, as its sides are prolonged as parallel carinæ the entire length of the metanotum; surface behind the areas transversely rugose, most roughly so behind the lateral spines. All pleuræ shining, more or less punctulate. Metathoracic spiracles elongate, four times as long as broad. Mesoëpisternal groove distinct only in front. Abdominal petiole smooth and shining, with a very few scattered punctures on the sides of the post-petiole. Second segment with deep gastrocœli, smooth at the very base; densely finely punctate elsewhere; third segment similarly punctate except at tip; following segments

faintly punctulate. Second to fifth ventral segments with a fold. Body of abdomen lanceolate, the second segment one-half longer than the third. Legs rather slender. Wings with the submedian cell longer than the median; discocubital vein with a faint stump of a vein near the middle. Areolet of moderately large size, slightly oblique, due to the insertion of the recurrent nervure beyond its middle; discoidal vein broken below the middle; transverse median vein in hind wing broken at its lower third.

Pará, Brazil. W. M. Mann. Named for Professor J. C. Branner, the director of the expedition.

This species exhibits an entirely different color scheme from its European congener, but agrees well in the more important structural details. It is the second species to be described and looks much like a genuine Ichneumon except for the palpi and spined metathorax.

Cryptus heathi sp. nov.

Female. Length 10 mm. Ovipositor nearly as long as the abdomen, exclusive of the petiole, Head, thorax and antennæ black, with yellowish-white markings; abdomen ferruginous, with narrow apical buff bands on the segments. The pale markings on the head and thorax are as follows; labrum, clypeus, except medially below; broad orbits, nearly meeting below the antennæ and covering the entire head behind below the vertex; joints 9–12 of antennæ; anterior edge of prothorax; lateral edges behind; medial spot on mesonotum; both scutellums; tegulæ; median stripes on metathorax behind carina, greatly widened behind; broad oblique stripe on mesopleura; another on posterior part of metapleura; spot behind wings; and a short stripe ventrally in front of each hind coxa. On the abdomen the white is at the base and apex of the petiole and as a narrow apical band on segments 2–7. The fore legs have the coxæ white, with black base and black spot in front and the basal trochanter white with black spot in front, the femur, tibia and tarsus fulvous with black stripe on femur above and last tarsal joint piceous. Middle legs pale ferruginous, with black spot on basal trochanter above, stripe on femur above and last tarsal joint piceous. Hind legs ferruginous, the apical two tarsal joints and tip of tibia blackened, and the three basal tarsal joints white. Wings hyaline, with piceous stigma and veins; the apex lightly infuscated and a narrow, irregular fuscous band just before the third discoidal cell, not ascending above the basal vein. Antennæ slender, 24-jointed, as long as the body; the joints very short apically, but much lengthened at the base of the flagellum; the first flagellar joint nearly as long as the eye and over six times as long as thick. Head twice as broad as thick; shining, finely margined behind, shining, sparsely punctate above the clypeus; the latter truncate; labrum exposed as a broad lobe; mandibles fuscous, black below; palpi pale, slender. Mesonotum finely, deeply punctate, the parapsidal furrows distinct and the median lobe produced forward

to the lateral ones. Scutellum nearly flat, punctulate. Metathorax evenly rounded above, finely closely punctate anteriorly, microscopically transversely rugose-aciculate behind, near the basal third with an evenly arcuate transverse carina; no trace of lateral projections or teeth; spiracles small, circular, behind them a very fine longitudinally impressed line to the base of the coxa. Pro-and mesopleuræ punctulate, a large smooth space below the insertion of the wings. Abdominal petiole shining, smooth, nearly straight below, bent above at the middle, with a longitudinal impression on each side, but without distinct carinæ; apex twice as broad as the base; spiracles barely behind the middle, second segment very finely, almost confluently punctate, following segments becoming smoother till at the tip the surface is not sculptured. Legs long and slender, the fore tibiæ swollen and greatly constricted at the base; fourth tarsal joint on all the legs very short and deeply divided for the insertion of the fifth. Wings with the stigma very narrow, radial cell narrow, as long as the cubito-discoidal; areolet small, scarcely narrowed above and with the second transverse cubitus less distinctly colored than its other sides; cubito-discoidal vein not broken; recurrent nervure received at the middle of the areolet; discoidal vein broken a short way above the middle; submedian cell shorter than the median; transverse median vein in hind wing broken well above the middle.

Independencia, Parahyba, Brazil. (Mann and Heath).

This is a very pretty species of intricate color pattern which resembles Callicryptus in the form of the tarsi, although it is otherwise very different. The areolet is unusually small, and recalls that of the Mesostenini. The color is also similar to certain Mesostenines, but I am quite positive that it is correctly located here.

Mesostenoideus (?) **crassus** sp. nov.

Female. Length 12 mm. Ovipositor one-half longer than the petiole of the abdomen. A stout species, with the general habitus of a *Cryptus*. Black, with joints 8–15 of the antennæ white above; a white median spot behind on the fifth to seventh segments of the abdomen, smallest on the fifth and largest on the seventh; legs, including coxæ bright ferruginous, the hind pair black beyond the trochanters, the middle pair beyond the knees, and the fore pair on the last tarsal joint; basal abdominal segments margined behind with rufous, especially below; wings hyaline, faintly infuscated; palpi fuscous at tips. Head broader than the thorax, nearly three times as broad as thick, arcuately excavated behind; subopaque. Front impressed and shining above the antennæ, with a fine median carina from the ocelli to the antennæ; cheeks and lower part of head behind the eyes smooth and shining. Mesonotum with distinct, sharp, but not broad parapsidal furrows which are strongly convergent behind; middle lobe scarcely elevated above the lateral ones. Scutellum slightly convex, margined at the sides of the base which is crossed by a broad, deep, longitudinally

fluted groove. Metanotum as long as the mesonotum, gradually declivous and impressed behind along the middle, the upper angles produced into sharp, pale-tipped thorn-like spines. One complete, transverse angulated carina just behind the spiracles and traces of a small median basal area. Spiracles elongate, over twice as long as broad; position of pleural carina indicated by a fine denticulate line. Surface of metanotum rugulose, with distinct transverse aciculations medially behind, its pleuræ very finely roughened. Mesopleura at the posterior margin with a grooved line which is crenate on its lower half; also with an arcuate linear impression above the center. Abdomen smooth, but opaque except on the petiole. Latter much broadened behind, the tip nearly four times as broad as the base; spiracles just before the posterior third; two carinæ above each carina which grow weaker apically; center of broadened portion longitudinally depressed. Second segment the longest, one-fourth shorter than the petiole, longer than broad at tip; following transverse. Legs stout, not much elongated Wings with black, narrow stigma and black veins. Median and submedian cells of equal length; cubito-discoidal vein broken, but little angulated by a slight tubercle. Areolet small, open, receiving the recurrent nervure near its outer angle; discoidal vein broken at the middle.

One female from Camp 39, Madeira-Mamoré R. R.

The generic reference is somewhat doubtful as the species has the stout antennæ and heavy-set body of a true member of the Cryptini. The areolet is so small, however, not closed externally, and of such characteristic Mesostenine form, that I think the species must be placed in this tribe, although it will probably find a place in a new genus.

Crypturopsis Ashmead.

There are two species in the collection obtained by the expedition, separable as follows:

1. Wings darker at tips; abdomen banded with black.....*minor* sp. nov.
   Wings not darker at tips; abdomen not banded with black..*brasiliensis* sp. nov.

Crypturopsis brasiliensis sp. nov.

Male. Length 11 mm. Head and thorax black with yellowish-white markings; abdomen and four anterior legs ferruginous; hind legs black beyond the trochanter. Wings subhyaline. The pale markings are as follows. Head both before and behind, below the level of the antennæ; inner orbits to the ocelli; large spot on each side of prothorax before and small one behind; four very much abbreviated longitudinal streaks on the mesonotum behind; spot on scutellum, a spot on each side of metanotum inward from the spiracle and a larger triangular one behind on each side; tegulæ, dash beneath them; two broad horizontal stripes on mesopleura; small basal and large medial spot on metapleura; middle part of fore coxa and middle coxa (except for irregular ferrugin-

ous marks). Fore and middle legs fulvous, paler apically and with the last tarsal joint black on the fore and the last two on the middle pair. Hind coxæ and a part of their trochanters ferruginous. Abdomen ferruginous except for the blackened tip of the petiole and small black stigmatal spots on segments 2–6, becoming obsolete on the later segments. Stigma and veins black. Head as broad as the thorax, nearly three times as broad as thick, rather thin and acute above; vertex punctulate; supra-antennal impression with a median carina and a few irregular radiating lines extending from the anterior ocellus; much deeper and shining just above the antennæ. Face slightly elevated medially, confluently punctulate. Antennæ 36–37 jointed evenly tapering to the apex, basal flagellar joint three times as long as thick, those at the middle twice as long as thick, and near apex, nearly quadrate. Clypeus at each upper angle with a fovea connected with the eye by a fine black line. Mandibles black at tips; palpi pale. Mesonotum closely punctate, without parapsidal furrows although there is a broad rugulose-reticulate streak in their place and between these behind are several short longitudinal striæ. Scutellum very convex, finely punctulate, with a broad, deep fluted furrow across the base which has high raised lateral margins. Metathorax reticulate-rugose, somewhat longitudinally depressed along the median line, its spiracles oval, twice as long as wide. Basal transverse carina present on each side, but curving forward to the margin on each side before attaining the median line; sides with a shallow groove from the spiracle to the base of the coxa, lateral angles produced as blunt teeth, coinciding with the lateral angle of the triangular pale spot. Thorax seen from above, scarcely more than twice as long as wide, truncate posteriorly. Abdominal petiole longer than the metathorax, slender, smooth, the post-petiole longer than broad, with parallel sides; following segments smooth and shining, sparsely clothed with fine, fulvous hairs. Areolet very small, open apically; submedian cell slightly shorter than the median; discoidal vein broken above the middle; transverse median vein in hind wing broken at its lower fourth.

Manaos, Brazil, Mann and Baker. One male.

Crypturopsis minor sp. nov.

Male. Length 9 mm. Similar to the preceding, but with less fulvous on the abdomen, and with the wings very distinctly infuscated apically and the antennæ only 31-jointed. Front before the ocelli rugulose, the median carina present. Color of head and thorax as in the preceding species, except that the post-scutellum is pale and the metathorax entirely black above except for the small rounded lateral pale tubercular teeth. The fore legs are pale yellow with the femora fulvus and infuscated at base and tip; the middle coxæ are yellow before and ferruginous behind and the apical three tarsal joints are black. The abdomen has the petiole entirely ferruginous and the post-petiole narrowed behind, while the following segments are black, with fulvus apical bands. Median and submedian cells of equal length. Otherwise as in *C. brasiliensis*, with the thoracic spots all somewhat smaller.

One male from the Rio Madeira (Madeira-Mamoré R. R. Camp 39), Brazil, Mann and Baker.

These are the first two South American representatives of the genus to be discovered, although three have been described from North America by Ashmead. Only one of these, dyari, is known in the female sex.

Cryptanura uniformis sp. nov.

Male. Length 12 mm. Head, thorax, and antennæ black, with white ornamentation; legs and abdomen, except part of petiole, bright ferruginous. The white markings are as follows; annulus of 6–7 segments on antennæ; clypeus except lower and side margin, face, wide anterior orbits, broad stripe behind eye, and palpi; prothorax with an elongate spot on each side above and below; mesonotum with a round spot on the middle lobe behind the tegulæ; elongate spot at side of scutellar fovea, scutellum and post-scutellum with side lines from each; metanotum with four broad longitudinal stripes on posterior half and a large spot at anterior angles; mesopleura with spot beneath wing and an elongate spot below; mesosternum with an elongate spot on each side. The legs also bear white on the anterior coxæ which are white in front and black behind, while the ferruginous middle coxæ are whitish in front. The ferruginous color is very uniform except that the anterior four legs and hind tarsi are more nearly fulvous. The apical joints of tarsi and the enlarged part of the abdominal petiole are piceous. The head is rather finely punctate on the face and clypeus, and the front bears two small spines above the antennæ; ocelli rather large, the posterior pair closer to one another than to the eye margin; eyes showing a very slight pubescence. Mesonotum deeply and sparsely punctate medially, nearly smooth on the sides, scutellum at the base with a very deep quadrate depression that is longitudinally striated. Metathorax with a complete transverse carina, joining a complete pleural one, and with a basal median and lateral area partly enclosed. Metathorax rugose-reticulate over its entire surface, more coarsely so behind, its spines long, slender, erect. Pro- and mesopleuræ smooth and shining, except for longitudinal striations below on the propleura and mesopleura. Mesopleura with a round impression medially behind, and rugose near the base of the coxa. Hind coxæ punctate near base. Petiole of abdomen very highly polished with a deep groove along the side passing below the spiracle which is situated just before the apical third of the petiole; following abdominal segments smooth, impunctate. Wings hyaline, infuscated at extreme tip; veins black, areolet very incompletely closed, the outer vein nearly hyaline. Submedian cell slightly shorter than the median; discoidal nervure inserted at the middle of the second discoidal cell; transverse median vein of hind wing broken at its lower fourth.

Described from a male taken by Mr. Wm. M. Mann, at Ceará-Mirim, Rio Grande do Norte, Brazil.

The present form approaches *C. hyalina* Brullé, which it resembles almost exactly in color, but the sculpture of the metanotum is very different.

Cryptanura striata Brullé.

Hist. Nat. Ins., Hyménop. Vol. 4, p. 244 (1846).

There is a male from Manaos (Mann and Baker) which appears to be this species, although differing from the female described by Brullé in having a short whitish stripe anteriorly on the inner edge of the lateral lobe of the mesonotum. The metanotal spines are blunt and the median metanotal stripes are abbreviated in front. The mandibles bear a large pale spot externally.

Polycyrtus histrio Spinola.

Ann. Soc. Ent. France, Vol. 9, p. 155 (1840).
Brullé, Hist. Nat. Ins., Hyménop. Vol. 4, p. 214 (1846).

There are two males of this species from Manaos (Mann and Baker).

Ophiogastrella Gen. nov.

Clypeus not pointed, truncate on the anterior margin. Eyes deeply, angularly emarginate on the inner margin. Face without a tooth, but with a faint cariniform tubercle just below the antennæ. Ocelli very large. Head strongly transverse, narrowed behind the eyes, the vertex not margined behind, although the temples and cheeks are distinctly margined. Mesonotum without furrows or parapsidal impressions at the anterior margin. Metathorax short, abruptly declivous; smooth, finely punctulate, entirely destitute of carinæ. Tarsal claws small, pectinate. Basal section of radius straight, not thickened; last section recurved. Submedian cell barely shorter than the median. Discoidal nervure arising at the upper fourth of the second discoidal vein. Disco-cubital vein very strongly bent, but not broken; its basal and apical portions running very nearly at right angles to each other. Cubito-discoidal cell without any dark chitinized spots. Transverse median vein in hind wing broken at its lowest fourth; the first section of the radius in this wing nearly twice as long as the recurrent nervure. Abdomen strongly compressed, very slender at the base, the first segment longer than the second, its spiracles placed at the apical third.

Type. *Ophiogastrella maculithorax* sp. nov.

This genus is related to *Pseudanomalon* Szépligeti, but differs in several important characters, particularly the form of the metathorax, which is neither elongate between the hind coxæ nor rugose-reticulate. From other related genera it differs

by the position of the discoidal nervure (*Banchogastra*) and by the absence of a transverse carina on the metathorax (*Pycnophion et al.*).

Ophiogastrella maculithorax sp. nov.

Female. Length 7–8 mm. Head, thorax and legs pale yellow; metathorax, antennæ at base and abdomen fulvus; remainder of antennæ and indistinct stains at anterior angles of metanotum more or less piceous; a large spot enclosing the antennæ and three broad longitudinal stripes on the mesonotum, deep blue-black. Of the mesonotal stripes, the lateral ones are abbreviated just before the anterior margin, and the median one extends from the anterior margin to just beyond the middle. Head smooth and shining; maxillary palpi slender, with the apical four joints subequal; face much narrowed below and the front above, by the eyes; the latter bare, almost attaining the base of the mandibles. Ocelli forming an equilateral triangle, separated by nearly their own diameter, the lateral ones very close to the eye margin. Entire thorax and pleuræ shining, smooth and polished, except for very fine punctulation on the mesonotum and metathorax. Mesopleura with a moderately distinct punctate impression medially. Abdomen very slender to the base of the third segment, then strongly enlarged and compressed; first segment slightly longer than the second; third, fourth, fifth and sixth subequal, each one-fourth shorter than the second; following segments very short. Ovipositor one-third shorter than the third segment. Wings hyaline, veins piceous, stigma fuscous. Legs very long and slender, tarsal claws small.

Described from three females, collected at light by Mann and Heath. Independencia, Parahyba, Brazil.

This is a small, slender species easily recognized aside from its structural characters, by the striking maculation of the mesonotum.

Ophionellus Westw.

Thesaur. Entom. Oxon., p. 128, Pl. 24, figs. 3, 3a, 3b, 3c. (1874).

Mr. Mann obtained a specimen of this remarkable genus which represents a species different from *O. fragilis* Westwood, the type of the genus. It agrees very closely with Westwood's species and is surely congeneric, but on comparing it with Cresson's *Pharsalia virginiensis*, I find that the latter is generically distinct, although the two genera have been regarded as synonomous.

The more salient differences may be tabulated as follows:

Pharsalia Cress. Sides of head behind the eyes rounded; antennæ short, filiform, about 25-jointed, but little longer than the head and thorax; anterior wing with a distinct, although small stigma.

Ophionellus Westw. Sides of head with a large tooth-like projection behind each eye; antennæ long, setaceous 40–50 jointed, nearly twice as long as the head and thorax; costa in anterior wing without thickening to form a stigma.

In addition to these differences the radial cell is much larger in *O. manni* than in *P. virginiensis*. The hind tibiæ bear two apical spurs in each case, not one as is stated by Szépligeti, although there is only a single one on the middle tibia.

Ophionellus manni sp. nov.

Female. Length 20 mm. (extended). Black, the face, clypeus, cheeks and mandibles, except teeth, yellowish-white. Fore coxæ and base of trochanters pale yellow, as are also the middle coxæ beyond the middle; fore legs rufous, slightly darker toward the knees, and paler on the base of the tarsi; middle tarsi pale on base of first joint; last segment of abdomen testaceous below. Head smooth above on the sides but rugose medially; above the antennæ with a deep depression which includes the median ocellus; face much narrowed below, only half as wide at the base of the eyes as at the antennæ, its surface shining and finely punctulate. Eyes pubescent; oval, nearly twice as long as wide. Head behind shining, punctulate, densely griseous pubescent on and about the tooth-like projection behind the eye. Head behind highly polished, margined. Ocelli large, in an equilateral triangle. Antennæ long and slender, 35-jointed; the first flagellar joint as long as the two following, rest gradually decreasing in length, those near the middle nearly three times as long as thick. Pronotum not visible from above, mesonotum much narrowed anteriorly. Its surface shining, reticulate, the carinæ forming quite regular transverse rectangular areolæ posteriorly. Scutellum sloping in a plane with the metathorax, flat, with a distinct large impression anteriorly. Metathorax long and strongly declivous, projecting considerably beyond the hind coxæ and bifurcate at its tip where the abdominal petiole is inserted. It is densely covered with very short silvery pubescence, but shows a distinct median groove and a lateral carina extending for its entire length. Besides these the surface is distinctly, but not sharply reticulated, the areolæ rectangular and transverse above and more or less polygonal on the sides. Pleuræ densely silvery like the metathorax except for the narrow smooth propleura and for a deep linear depression extending from the middle coxa to the tegula. This groove is coarsely reticulated. Abdomen very slender, the petiole as long as the entire length of the thorax above, swollen on the apical two fifths where the spiracles are placed; its surface smooth and shining, the remainder of the abdomen dull; second segment as long as the first; third, half as long; fourth almost equalling the second; fifth equalling the second; sixth, seventh and eight short. decreasing in length; ovipositor as long as the third segment. Wings perfectly hyaline; radial cell as long as the cubito-discoidal cell, the second section of the radius and the transverse cubitus interstitial; second discoidal cell as high as long above, narrowed behind; costa

without a stigmal thickening; costal vein extending beyond the radial cell for half its length. Hind wing with a single subcostal cell, and the same continuation of the costal vein. This costal projection and the costal vein in the anterior wing black, but otherwise the venation is pale fuscous.

Described from one female collected by Mann and Baker on the Rio Madeira, Brazil, Camp 39, Madeira-Mamoré R. R.

This species differs from *O. fragilis* Westw. the only other described member of the genus, by the absence of a median groove on the mesonotum and by the entirely black tibiæ. The second discoidal cell is also much shorter than the form represented by Westwood's plate.

Family BRACONIDÆ

Subfamily HELORIMORPHINÆ

Helorimorpha brasiliensis sp. nov.

Male. Length 4 mm. Entirely honey yellow, except the space between the ocelli, the entire antennæ, (except the 16th and 17th joints which are rufous) the apical fourth of the hind tibiæ, the hind tarsi and the apical joint of the other tarsi which are black. Wings deeply infuscated, blackish; with black stigma and veins. Head twice as wide as thick antero-posteriorly, smooth except for fine punctulation on the face and clypeus and still finer on the head above. Eyes small, nearly circular, one half longer than the malar space. Front with a sharp median carina extending from the upper part of the face nearly to the ocelli; strongly excavated above the base of each antenna. Ocelli small, close together in a triangle, separated by only their own diameter. Maxillary palpi slender, pale testaceous; 5-jointed, with the basal joint very short. Antennæ black, with the 16th and 17th joints distinctly rufous; scape nearly as long as the first flagellar joint and twice as long as the pedicel; third joint as long as the scape, swollen apically; following joints becoming shorter and distinctly moniliform by the middle of the flagellum, where they are only half longer than thick; again toward the tip the joints become much more slender and lose their moniliform shape. Thorax pitted and reticulate as in other species of the genus, the metathorax deeply excavated medially on its posterior face. Abdomen slender, as long as the head and thorax; petiole curved near its apical third; very slender, but distinctly broadened toward tip both in dorsal and lateral view; spiracles at the posterior third; base not striated. Second segment covering all the remaining parts of the abdomen, smooth and highly polished; narrowly ovate; one third as broad as long and slightly higher than broad; much more strongly curved below than above. Legs formed as in the other species. Wings with the radius arising perpendicularly from the middle of the stigma, the latter nearly half as broad as long; second section of radius nearly half as long as the first and as long as the hyaline second transverse cubitus. Recurrent nervure joining the upper side of the second cubital cell in a straight

line and the lower side originating at the same point so that the cell is thus three-sided. Submedian vein bordered by a hyaline streak as in *H. fisheri.*

One male collected by Mann and Baker; Manaos, Brazil.

This species is very similar to *H. fisheri* Viereck from eastern North America, and aside from the form of the antennæ and wing venation differs only in its color characters. Mr. Mann's discovery of the Brazilian form is very interesting as the first representative of the genus was discovered in 1907 by Schmiedeknecht in Europe. Shortly afterwards it was found to occur in North America.

The four species so far described may be separated as follows:

1. Wings infuscated; body yellow.....2
   Wings hyaline; at least head black.....3
2. Scape of antennæ yellow; flagellar joints twice as long as thick.....
   H. fisheri Viereck
   Antennæ entirely black, except joints 16 and 17; flagellar joints near middle of antennæ less than twice as long as thick.....*H. brasiliensis* sp. nov.
3. Body entirely black.....*H. egregia* Schmiedeknecht
   Body, except head, yellow.....*H. melanderi* Brues

Subfamily MICROGASTRINÆ

Mirax brasiliensis sp. nov.

Female. Length 2.2 mm., ovipositor as long as the head-height. Head and thorax pale honey-yellow, abdomen somewhat lighter; legs whitish-yellow; antennæ fuscous beyond the second joint; wings hyaline, with pale testaceous stigma and veins. Head transverse, twice as wide as thick, rounded on the temples behind the eyes; ocelli in an equilateral triangle, the space between them one third as great as that between the lateral ones and the eye margin. Front excavated on each side above the antennæ, the depressions separated by an elevated triangular space that extends down to the level of the antennæ. Face smooth; elevated medially, broadly so below and narrowly so above where the median line is almost carinate. Clypeus separated by a depressed line and with a large circular fovea on each side, its lower edge projecting but straight in front view. Mandibles black at tip, with two small teeth at apex. Antennæ 14-jointed, as long as the body, tapering; scape short, but little longer then the pedicel which is slightly more than half as long as the first flagellar joint; joints beyond growing very gradually shorter, none less than two and one half times as long as thick. Eyes elongate-oval, much narrower below; malar space very short, with furrow. Mesonotum with crenulate furrows on its anterior half; sharply narrowed in front of the tegulæ. Scutellum long, with parallel sides behind, but widened in front, its base with a curved, deep, linear impression which is crossed on its bottom by numerous carinæ. Metanotum irregularly areolated; with a median carina that bifurcates behind, a straight transverse carina behind, and a curved carina on each side at the base

which marks off a large squarish space at each lateral angle, and with a lateral carina which passes just outside the round spiracle. Mesopleura with a carina along its posterior edge. Abdomen sessile, as long as the head and thorax. First segment with a L-shaped shining elevated portion; the latter swollen anteriorly and widened laterally along the margin of the segment; remainder of the segment paler, whitish; second segment twice as broad as long, longitudinally striated, also pale; following segments shining and smooth, fully colored. Ovipositor ferruginous, its sheaths broad, pilose, piceous with pale yellow bases. Legs moderately stout, blackened on the tips of the tarsi. Wings with broad stigma that is produced apically into a long, narrow point; marginal cell entirely wanting; submedian cell longer than the median by the length of the transverse median vein; recurrent nervure received at the apical fourth of the first cubital cell; second cubital wanting, except for a short stump of a vein that indicates its lower basal corner; subdiscoidal vein wanting. Hind wing with only the median and submedian cells, the latter less than half as long as the former.

One female, Ceará-Mirim, Rio Grande do Norte, Brazil (W. M. Mann).

This is possibly not congeneric with the type of *Mirax* on account of its parapsidal furrows, although otherwise similar.

Subfamily CHELONINÆ

Chelonus brasiliensis sp. nov.

Female. Length 3 mm. Black; the antennal scape, mandibles, anterior legs, including most of their coxæ; trochanters, tip of femora and basal half of hind tarsi dull fulvous-yellow; palpi, tegulæ and four posterior tarsi whitish yellow. Wings subhyaline; stigma black; veins piceous, lighter brown toward the base of the wing. Head transverse, twice as broad as thick, and very short behind the eyes; finely confluently punctate on the vertex, transversely rugulose on the front and face; head behind and cheeks smooth, scarcely punctulate. Eyes oval, thickly clothed with pale pubescence, nearly twice as long as broad; malar space half the width of the eye. Ocelli in a small triangle, the posterior ones closer to one another than to the eye margin. Antennæ in a deep depression; 19-jointed, the scape subcylindrical, curved, as long as the first two flagellar joints together; first flagellar joint nearly three times as long as thick, the following becoming gradually shorter and thinner, the subapical one quadrate. Clypeus separated from the face by a sharp suture, with a foveate puncture near each side; arcuately rounded on its anterior margin; palpi normal, pale yellowish. Mesonotum and scutellum rugose-punctate, the parapsidal furrows and a scutellar margin more or less distinctly indicated by a series of larger, more regular punctate impressions. Scutellum, aside from its basal strip, nearly triangular. The basal strip sculptured across its entire extent by a series of large squarish foveate impressions. Metanotum short, declivous, rugose reticulate with several somewhat irregular areas behind. Abdominal carapace oval, rather coarsely rugose anter-

iorly; very finely so posteriorly; rounded behind. The apical opening oval twice as broad as high. Pleuræ rugose-reticulate, more coarsely so behind. Legs very stout, especially the hind pair. Stigma broadly oval, over half as broad as long, emitting the radius just beyond its middle; parastigma distinct, fuscous. Radial cell short, the postmarginal vein no longer than the stigma; length of first, second and third sections of the radial vein in the proportions of 2, 3 and 7. Submedian cell longer than the median by the length of the first section of the radius; recurrent nervure interstitial with the first transverse cubitus which it equals in length; discoidal vein broken near its lower end.

Natal, Brazil. One specimen collected by Mr. W. M. Mann. This is the first South American species to be described.

There are two other specimens, somewhat smaller and with darker legs, from Independencia, which may possibly represent another species, but structurally, there are only slight differences.

Phanerotoma trivittata sp. nov.

Male. Length 5 mm. Buff-colored, the abdomen paler, almost cream-colored; head above and hind femora yellowish; first joint of antenna fuscous, the flagellum pale ochreous yellow. Marked with black as follows; tips of mandibles, a dumb-bell shaped spot between the ocelli; an elongate spot on the mesonotum anteriorly, a longitudinal stripe on the parapsides; scutellum; spot on mesopleura below base of wing; spot before tip of all femora; anterior and middle tibiæ, except base; extreme base and apical third of posterior tibiæ. Wings yellowish at base with yellow veins and stigma; apically subhyaline, with fuscous veins, stigma slightly mottled with fuscous. Head one half broader than thick, arcuately rounded behind the prominent eyes; vertex finely rugose, the ocelli close together, the hind ones five times as far from the eye as from one another. Front just above the antennæ with a margined depression which includes the anterior ocellus and bears a fine raised median line that extends halfway down the face; face finely rugose. Antennæ 23-jointed, tapering; as long as the body; scape almost cylindrical, as long as the first flagellar joint which is four times as long as thick; following gradually growing shorter, at middle of antenna three times as long as thick. Eyes bare, cheeks with an indistinct malar groove half as long as the diameter of the eye. Head behind finely punctulate. Mesonotum faintly rugulose, with feebly impressed parapsidal furrows. Scutellum triangular, longitudinally rugulose, the thoracic dorsum longitudinally striated on each side of the scutellum. Metanotum rugulose, exareolated, the upper hind angles produced into short blunt teeth. Abdomen as long as the thorax; three segmented, the third segment longest; first a little shorter and second still shorter; its upper surface longitudinally rugose-aciculate, less distinctly so on the third segment; first segment with a carina arising at the anterior angle, slanting toward the median line and fading out at the middle of the segment. Apex of abdomen rounded. Pleuræ faintly roughened. Hind legs much thickened, others slender. Wings

with the submedian cell longer than the median; subdiscoidal vein arising near the lower angle of the second discoidal cell; recurrent nervure inserted near the base of the second cubital cell; second section of the radius a little longer than the first; second transverse cubitus half as long as the first.

Manaos, Brazil (Mann and Baker).

This species is very distinct on account of the disposition of its peculiar pale color and sharp black maculation.

Subfamily CENOCŒLIINÆ

Cenocœlius tricolor sp. nov.

Female. Length 9 mm., ovipositor 7 mm. Head above the level of the antennæ, spot above hind coxa, four posterior legs and abdomen above, except on the sides, black; remainder of head and thorax honey-yellow except the metanotum behind which is whitish, and also the anterior legs, except most of the femora and the apical tarsal joint. The abdomen is maculate with yellowish white as follows: hind angles of petiole; a band along each side of segments 3–7 which extends inwards half way to the median line along the sutures; these incisures narrow and pointed except at the base of the third segment where they form a broad, widely interrupted transverse basal band. Sides of abdomen whitish; ventral plates black. Wings blackish with a hyaline streak crossing at the insertion of the recurrent nervure. Head twice as broad as thick, arcuately emarginate on the occiput; vertex with a deep median depression extending down the front to the base of the antennæ. The median ocellus lies at the bottom of the depression and the lateral ones on the edge, a carina extending downward from each to the level of the antenna; sides of front and face sparsely punctate; middle of face confluently so; clypeus punctate like the face. Eyes small, rounded oval, as long as the malar space. Posterior edge of head with a high raised margin. Antennæ 32-jointed; scape cylindrical, three times as long as thick; first flagellar joint slightly longer than the second which is three times as long as thick; joints near the middle twice as long as thick. Mesonotum with coarse punctate parapsidal furrows, the middle lobe prominent, twice as long as the lateral ones and prolonged backward between the convergent furrows as a raised line. Scutellum with a broad impressed line at the base composed of four large foveæ. Metathorax above irregularly reticulate; behind and on the sides rugose reticulate. Propleura sparsely punctate; mesopleura smooth with a crenulate mesoëpisternal furrow, a carinate posterior margin and several foveæ above. Abdomen polished; first segment one-third as broad at base as at apex, longer than the width at apex (exclusive of the white corners); with a number of curved carinæ on each side of a median smooth space, the median pair of carinæ attaining the base and the lateral pair the apex of the segment; second segment more closely striated except around the edges and on a median stripe which is smooth and slightly elevated into an obsolete tubercle anteriorly; following segments smooth and highly polished. Legs

stout, thickly hairy on the tibiæ and tarsi, sparsely so elsewhere. Stigma lanceolate, black; second section of radius one-half longer than the first and one-third the length of the third; second cubital cell narrowed above, its tip one-half as high as its base; recurrent nervure received at the apex of the first cubital cell; submedian cell longer than the median; subdiscoidal vein arising from the apex of the discoidal vein, the second discoidal cell narrowly open at this point; first section of cubitus straight; submedian cell in hind wing two-thirds as long as the median.

One female from Camp No. 28, Madeira-Mamoré R. R. Co., Rio Madeira, Brazil (Mann and Baker).

This species will be easily recognized on account of its striking color.

Subfamily BRACONINÆ

Binarea calida sp. nov.

Female. Length 13 mm., ovipositor 11 mm. Black, ferruginous and fulvous; wings yellowish with fuscous tip and a median transverse piceous band. Black as follows; head, antennæ, prothorax except hind part of pleuræ; mesosternum and large blotch on mesopleura; hind legs with coxæ, spot on hind femora above at base, knees, stripe on outer side of tibiæ and entire tarsi; apical joint of fore and middle tarsi; abdomen beyond third segment (the fourth fuscous) and ovipositor. Thorax otherwise ferruginous, and the legs and abdomen fulvous. Wings with the venation pale fuscous on the clear parts, black elsewhere; stigma black, rufous below apically. Wing tip fuscous from just beyond the second transverse cubitus, the dark cross-band embracing the basal half of the first cubital cell and the apical half of the first discoidal; fore wing also with a hyaline spot in the radial cell and a large one behind the second cubital cell. Hind wing fuscous beyond the base of the radial cell. Head one-fourth broader than long, entirely smooth above; face irregularly rugose, slightly elevated into an indistinct tubercle medially which is more finely rugose; just below each antennal tubercle a short deep groove meets the one of the opposite side to continue upwards between the antennal tubercles. Malar space and cheeks sparsely punctate. Eyes nearly round, twice as long as the malar space. Antennæ long and slender, the joints not distinctly separated; scape and pedicel fringed at tip with ferruginous hairs as in *B. spinicollis*. Palpi pale yellow, the lower side of the head clothed with long buff-colored hairs. Pronotum margined in front; medially behind with a short blunt spine or tooth; prothorax below near the middle with a sharper thorn-like tooth on each side and a second conical elevation or tooth on the anterior margin further forward. Prothorax smooth above and on the sides, finely and densely punctate below. Mesonotum with the middle lobe twice as long as the lateral ones, the parapsidal grooves deep, but impressed only anteriorly. Scutellum immargined, with two large deep, quadrate depressions at the base. Metathorax with a median furrow, more distinct anteriorly and with a large, deep impression behind on each side of the middle. Thorax

smooth except the metapleuræ which are sparsely punctulate. Pro- and metapleuræ thinly clothed with pale hairs. Metathoracic spiracles small, elongate oval. Abdomen as long as the head and thorax together; its surface shining, impunctate. First segment scarcely widened apically, twice as long as broad at tip, the median portion raised and carinate laterally at the base; toward each side with a carina separated from the median elevation by a broad smooth groove and from the extreme lateral edge by a linear furrow. Second segment fused with the third, but the suture indicated medially by a broad crenulate furrow; anteriorly with a trifoliate elevation consisting of a narrow pointed median elevation and lateral ovate elevation; sides of second segment separated from the median part by a longitudinal impressed line and from the base of the third by an oblique impressed line. Third segment with a small lozenge-shaped tubercle medially at the base, on each side of which is a large, faintly raised elevation; anterior angles also slightly elevated into a rounded convexity. Following segments not sculptured. Legs stout, the hind pair considerably thickened; fore tarsi distinctly more than twice as long as their tibiæ, each of which bears along its front side a series of five short, stout fuscous spines or thorns. Tarsal claws large, simple, wings with the submedian cell longer than the median by one-fifth the length of the basal vein; recurrent nervure received at the apical sixth of the first cubital cell; discoidal nervure arising at the posterior angle of the second discoidal cell. Submedian cell in hind wing more than half the length of the median; radial cell divided by a cross-vein.

One female from Abuná, Rio Madeira, Brazil, Mann and Baker.

This species differs from *B. spinicollis* Brullé, the only species hitherto described, by its entirely red mesonotum, red middle coxæ, and the much greater amount of black on the abdomen. Brullé does not mention the second pair of teeth on the margin of the prothoracic pleuræ, nor the spines on the anterior tibiæ. These may be present in his species, but it does not seem possible that he could have overlooked both these striking characters.

Parabinarea Gen. nov.

Similar to *Binarea* Brullé, but differing by the presence of three spinose tubercles on the pronotum, the absence of tubercles on the propleuræ, the structure of the metathorax, which is covered with flat, circular impressions, and the aciculate sculpture of the first two abdominal segments.

Head nearly quadrate, strongly rounded off behind and excavated on the occiput; with a large shallow impression above the antennæ which are long slender and many jointed. Pronotum with a pair of spinose tubercles near the anterior margin, and with a single median one behind. Propleuræ convex, not tuberculate. Mesonotum with deep

parapsidal grooves, the median lobe extending far forward of the lateral ones; scutellum flat, with a pair of large foveæ at its base; postscutellum produced into a minute spine or tubercle. Metathorax not areolated, but covered with well-separated rounded shallow impressions above. Along the median line there is an indistinct carina with a series of these impressions on each side, then a narrow smooth space reaching back to the middle of the segment, followed by a lateral area of impressions. The metapleuræ are smooth above and very coarsely reticulate below; apex of metanotum with three deep impressions. Mesopleura smooth, separated from the metapleura by a deeply impressed line composed of large foveate punctures. Thorax as a whole long and somewhat flattened. Abdomen as long as the head and thorax; first segment but little widened behind, carinate; second and third tuberculate; first two segments longitudinally aciculate; second and third fused. Ovipositor long. Legs stout, the fore tibiæ in front with a series of five short, thorn-like spines. Tarsal claws small, simple. Wings as in *Binarea*, the submedian cell longer than the median; radial cell in hind pair divided by a cross-vein.

Type: *P. manni* sp. nov.

This is a most remarkable form on account of the peculiar sculpture of the metanotum. It is very clearly related to *Binarea*.

Parabinarea manni sp. nov.

Female. Length 8–11 mm., ovipositor 7–8 mm. Fulvous and black, the wings yellowish, bifasciate with black. The fulvous color is distributed as follows; tegulæ; entire metathorax; first four segments of abdomen and often fifth, except for spot in front and a band behind; fore coxæ almost entirely; anterior and middle legs, except tips of last tarsal joint; hind legs on second joint of trochanters, basal four-fifths of femora, and basal third of their tibiæ. Palpi pale yellow. The apex of the hind wing, and that of the fore wing beyond the basal fourth of the third cubital cell is black, and the black cross-band on the fore wing embraces the stigma and wing from the origin of the cubitus to the origin of the radius; there is a faint oblique hyaline streak in the first cubital cell and a hyaline spot below the insertion of the recurrent nervure. Head smooth above, the frontal depression immargined, shallow, almost surrounding a small elevation which bears the closely approximated ocelli. Face finely rugose at the middle, very coarsely so on the sides, the furrow between the antennal tubercles not extending down onto the face. Cheeks finely punctulate, malar space two-thirds as long as the diameter of the eye. Head behind punctulate and sparsely clothed with long white hair which is also present on the orbits, clypeus and sides of the face. Palpi long and slender. Pronotum above impunctate; pleuræ punctate, with an oblique carina for their entire length. Triangular part of pronotum that extends toward the tegulæ separated from the collar by an oblique impression that bears a number of raised cross-lines. Mesonotum smooth, the parapsidal furrows strongly convergent, not reaching the scutellum, but continued

to the latter as a pair of *raised* lines. Scutellum with a pair of large quadrate depressions at the base separated by a fine median raised line. Mesopleura elevated along its upper edge and near the upper anterior angles, and with an oblique impressed groove (larger behind) below. Metathorax as described in the generic diagnosis, its lateral angles slightly toothed. Abdomen as long as the head and thorax together; first segment but little widened apically, the central raised portion bordered by lateral carinæ and with a pair of converging carinæ on its disk, on the sides with a carina above the lateral margin; its surface coarsely aciculate except at the base of the median lobe. Second segment with a pair of approximate rounded elevations behind and with a deep moderately oblique groove from each anterior angle which defines a triangular lateral piece. Third segment tuberculate, raised in front on each side of the middle and also at the anterior and posterior angles; following segments smooth. Legs stout; fore tarsi twice as long as their tibiæ; hind femora much thickened, less than four times as long as broad. Wings with lanceolate stigma which is black before the origin of the radius, and pale brown beyond; veins dilute fuscous, piceous under the black markings; submedian cell longer than the median by one-third the length of the transverse median vein; recurrent nervure received at the apical sixth of the first cubital cell; discoidal nervure arising at the posterior angle of the second discoidal cell. Hind wing with the submedian cell two-thirds as long as the median; the resurrent nervure distinct.

Four females from Abuná, Rio Madeira, Brazil, collected by Mann and Baker.

Cervulus nodicornis (Brullé).

Hist. Nat. Ins. Hyménop. IV, p. 408. (1846) (*Bracon*).

Mr. Mann obtained a female of this species at Baixa Verde, Rio Grande do Norte. It agrees well with Brullé's description, except that it is a trifle smaller (12 mm. ovip. 6.5 mm.) and the vertex is rufous like the rest of the body.

Bracon paraensis sp. nov.

Female. Length 4.5 mm., ovipositor 1.4 mm. Honey-yellow marked with black, paler on the lower parts of the head and abdomen below. The following parts are black: antennæ; broad bands on the second, third, fourth and fifth segments, all of equal length and crossing the fifth segment completely but leaving broad pale lateral spaces on the more anterior segments; sixth segment entirely; ovipositor sheaths, apical joint of four fore tarsi; and hind legs beyond the trochanters, although with the knees and tarsal articulations yellowish. Wings deeply infuscated, more strongly so at the base. Head two and one-half times as broad as thick, rapidly narrowed behind the eyes and not excavated behind. Vertex smooth, ocelli equidistant, separated from one another by their own diameter. Front shagreened medially, with a central finely impressed line above the antennæ to the ocelli. Antennæ

37-jointed; scape short, obliquely truncate at tip, less than twice as long as thick; flagellar joints all about one-half longer than broad, the first longer, twice as long as thick. Face smooth, with a slight convexity below the antennæ. Clypeus deeply impressed along its upper margin and with the lower edge narrowly reflexed. Head behind smooth, cheeks sparsely punctulate. Palpi slender. Eyes four times as long as the malar space. Mesonotum not noticeably trilobed; parapsidal furrows distinct, complete, scarcely convergent posteriorly; its surface smooth and shining. Scutellum nearly flat anteriorly, with a transverse crenate furrow across the base. Metanotum with a very much abbreviated median carina posteriorly which is continued in front as a very finely impressed line. Pleuræ shining; mesopleura with a small median circular impression. Metapleura with a deep horizontal sulcus just below the small circular spiracle. Abdomen short, ovate. First segment with a pair of divergent grooves that define a triangular elevation medially on the segment behind. Second segment with a pair of small oval, very deep and sharply defined impressions anteriorly near the median line and also on each side with a much more feebly impressed and irregular longitudinal depression. Third segment on each side basally with a somewhat oblique transverse impression that does not reach the lateral margin however; fourth and fifth segments with similar transverse impressed grooves at the middle of the segment, these are not oblique and reach the sides of the abdomen, simulating additional intersegmental sutures. Legs slender, sparsely clothed with pale testaceous hairs as is the entire body in an irregular way. Wings with the stigma lanceolate, black, as are also the veins. First section of the radius as long as the width of the stigma; second segment twice as long; second cubital cell with parallel upper and under sides, the first transverse cubitus very oblique and the second vertical; recurrent nervure received just before the tip of the first cubital cell.

One female collected by Mr. Wm. M. Mann at Pará, Brazil.

In general appearance this is very much like the nearctic *Microbracon mellitor* and its alies, but the sculpture of the abdomen is of an entirely different type.

Iphiaulax xantothorax Brullé.

Hist. Nat. Ins. Hyménop., Vol. IV, p. 393 (1846). (*Bracon*).

There is a female from Porto Velho, Rio Madeira, Brazil, which agrees well with Brullé's description. The specific name is evidently intended to be *xanthothorax*, but the spelling given above appears in the original.

Bracon crassitarsis sp. nov.

Female. Length 10–11 mm.; ovipositor 7–7.3 mm. Pale ferruginous with head, most of legs and abdomen beyond fifth segment, black; wings blackish, yellow at base. The black is as follows; head except base of mandibles and tip of last palpal joint; antennæ; prothorax, except upper hind angles; metathorax; fifth abdominal segment (some-

times in part); all following segments; ovipositor and its sheaths; legs, except anterior knees and four basal joints of anterior tarsus; the middle tarsi brownish on first four joints. The wings have the stigma black and are strongly infuscated beyond the basal vein, though pale yellowish toward the base. Head nearly twice as wide as thick, rounded and narrowed behind the eyes. Front above the antennæ with a deep depression that is divided by a fine, sharp median carina; antennal tubercles rather short. Face finely rugose, faintly reticulate, with a vertical raised line extending from each antennal tubercle to the clypeus and a second near to the eye. Clypeus crescentic, margined above by a fine line and fringed below with a brush of porrect pale yellow hairs. Eyes large, oval, fully five times as long as the malar space. Antennæ a little shorter than the body; scape as long as the width of the eye, broadened apically; first flagellar joint nearly twice as long as wide; second not quite half longer than wide; following nearly quadrate. Mesonotum with the parapsidal furrows impressed anteriorly, convergent. Scutellum with a smooth impressed line across the base. Metathorax smooth and polished; sparsely punctulate on the sides. Abdomen elongate, as long as the head and thorax, and but little wider; raised median portion of first segment narrowed in front, but attaining the base of the segment; close to it on each side is a carina. Second segment with a small median tubercle in front, on each side of which is a foveate depression, without lateral carinæ or separated corners; its suture with the simple third segment smooth. Third segment the longest, nearly half as long as broad. Mesopleura with the femoral furrow narrow; the metapleural depression rather deep and lying just outside the elongate reniform spiracle. Legs stout, the tarsi much shortened and flattened, especially those of the middle and fore legs; clothed with sparse, glistening pale hairs, denser on the tibiæ and black on the hind ones. Wings with the stigma lanceolate; submedian cell as long as the median; first section of cubitus strongly curved so that its base runs nearly parallel for a short distance, its origin being at the upper third of the basal vein; recurrent nervure received at the apical fifth of the first cubital cell; first section of radius one-third as long as the second and two-thirds as long as the first transverse cubitus; second transverse cubitus slightly oblique, with a hyaline spot near its top and bottom; discoidal vein broken at its lower third.

Male. Length 9 mm. In this sex the anterior tibiæ are almost entirely fulvous; the second trochanters of the fore and middle legs are ferruginous and the first four joints of the middle tarsi are yellowish. The tarsi are not thickened and their pile is dark, except on the anterior pair. Palpi entirely pale. The black on the fifth abdominal segment is also more extensive, covering the surface except on the sides and the posterior edge.

Five specimens, four females and one male from Rio Madeira, Brazil (Camp 39, Madeira-Mamoré R. R.) Mann and Baker.

This is a very distinct species on account of the peculiar form of the tarsi in the female and the conspicuous color pattern.

Bracon thalessiformis sp. nov.

Female. Length 18 mm.; ovipositor 55 mm. Black, with most of the thorax and the first segment of the abdomen pale ferruginous. Wings blackish, with a pale band before and another after the middle. The ferruginous thorax has the prothorax black, except on its posterior third and the metathorax is blackish medially, in addition to a triangular black spot on each side before the hind coxa. The second abdominal segment is tinged with brown and ferrigunous along the sides and the venter is colored almost as the dorsal aspect. The fore wing is black at the base, becoming paler to the end of the submedian cell, when it is black to the base of the radial cell, then pale through most of the second cubital and finally blackish beyond to the tip. The hind wing is blackish, with an incomplete pale band at the middle. Head scarcely wider than thick, sharply excavated behind at the middle of the occiput, the face receding so that it is almost horizontal. Eyes small, round, removed by their own diameter from the base of the mandibles; surface smooth and polished above and behind, sparsely punctulate on the cheeks. Face subshining, closely punctulate except for a small, nearly smooth, central portion; clypeus shining, with a complete, fine, sharply raised margin. Front with a shallow depressed space including the ocelli; antennal tubercles rather small. Antennæ as long as the body; scape cylindrical, elongate, nearly as long as the thickness of the head; first flagellar joint twice as long as thick; second one-half shorter; remainder nearly quadrate. Palpi long, very slender, the last joint yellowish at tip. Prothorax smooth and shining. Mesonotum without parapsidal furrows, although the median portion is somewhat produced anteriorly. Scutellum with a narrow, smooth groove separating it at the base from the mesonotum. Metathorax without carinæ, polished, smooth except for small very sparse punctures on the sides. Abdomen long and narrow, no wider than the thorax. First segment one-half wider at apex than at base, its median elevation ovate, pointed anteriorly, on each side of this with two smooth grooves separated by a carina before the raised margin; second segment one-half longer than broad; smooth, except that the anterior corners and the lateral margins are separated by a smooth groove from the central portion; third segment about quadrate, the anterior angles very indistinctly separated, following segments growing shorter; hypopygium longer than the pygidium. Pleuræ smooth, with a deep femoral groove extending from the fore coxa to the root of the hind wing and a less pronounced groove just external to the oval metathoracic spiracle. Legs long and rather slender, with the hind femora clavate. Wings with the submedian cell indistinctly longer than the median, recurrent nervure interstitial with the first transverse cubitus; first section of the radius one-fifth as long as the second and half as long as either of the transverse cubiti; second transverse cubitus with its lower half perpendicular, but strongly bent toward the wing tip above; discoidal vein broken at its lower two-fifths. Stigma black, fulvous on its lower half.

One female from Rio Madeira, Brazil (Madeira-Mamoré R. R. Co., Camp 39), collected by Mann and Baker.

This is a very remarkable species on account of the long ovipositor, although several others are known in which this organ attains a similarly great length.

Iphiaulax Förster.

Of this genus, so richly represented in the neotropical fauna, a considerable number of species were obtained, at least five of which are undoubtedly undescribed. These may be separated as follows:

1. Wings dark at apex.....2
   Wings with dark cross-band, but the anterior ones white at apex.*I. reduvioides*
2. Wings with distinct dark cross band before apex.....4
   Wings without distinct dark cross-band before the dark apical portion; legs in part pale.....3
3. Face with a median furrow or depression, abdomen rather narrow; length 12 mm.....*I. fortis*
   Face not excavated medially; abdomen rather broad, length 7.5 mm..*I. starksi*
4. Legs entirely black abdomen broad; ovipositor shorter than abdomen.....*I. carapunæ*
   Legs in great part pale; abdomen slender; ovipositor longer than the body. *I. abunensis*

Iphiaulax reduvioides sp. nov.

Female. Length 11 mm.; ovipositor 5 mm. Black, with the first abdominal segment except the apical portion of the central elevation, the sides of the second and third, extending inwardly somewhat along sutures, and the extreme lateral edge of the fourth, rufous. Tips of maxillary palpi yellow. Wings pale brown at the base nearly to the basal vein, then with a black band which includes over half of the second cubital cell, and apically white. Basal third of stigma bright fulvous, the color extending somewhat into the upper part of the first cubital cell; third discoidal cell with a hyaline spot basally above, hind wing black on apical half, basally pale brown. Venter fulvous on second, third and fourth segments, black beyond. Antennæ as long as the body and ovipositor together, head one half broader than thick, obliquely narrowed behind the eyes; ocelli surrounded by a grooved line; face finely rugulose punctate, slightly convex, with a faint, fine median carina, and an indistinct grooved line on each side near the eye-margin; front and vertex shining, impunctate, the former extending between the antennal tubercles as a polished median groove, malar space very short. Mesonotum highly polished, the parapsidal furrows smooth, but slightly convergent and obsolete behind. Scutellum smooth, with a line of large confluent punctures at the base. Metathorax without carinæ, smooth medially, punctulate laterally. Abdomen broadly oval, much wider than the thorax, the first segment quadrate, not narrowed basally, the swollen pleural portions visible from above on each side, as wide as the segment and blackish-yellow in color; median elevation narrowed

and rounded basally, separated from the lateral carinæ by a broad, smooth groove. Second segment four times as broad as long, the median field narrow, much attenuated behind. Third segment without median line or carina, the lateral angles separated by deep grooves; barely longer than the second medially and much shorter laterally, excluding the produced lateral angles. Third and fourth segments each divided by a transverse groove, the third with the lateral angles separated. Ovipositor fuscous, its sheaths black. Wings with the venation fuscous basally, black at the middle, and pale brown on the hyaline apical portion; second cubital cell half as long as the marginal, nearly one half longer below than above; recurrent nervure received almost at the apex of the first cubital cell, parallel with the first transverse cubitus.

One female from Abuná, Rio Madeira, Brazil, Mann and Baker.

This is a stout, heavy-set species with quite conspicuously pilose shining body and densely hairy legs.

It resembles most closely two neotropical species, *I. tristis* and *I. semialbus* recently described by Szépligeti (Termes. Füzetek., Vol. 24, p. 397, (1901)), but may be easily distinguished from the first by the form of the first abdominal segment and the wing pattern, and from the second by the absence of a carina on the third segment and the different color of the wings. It is a very striking form, reminding one of a Reduviid bug in shape.

Iphiaulax fortis sp. nov.

Female. Length 12 mm., ovipositor 9 mm. Black, palpi pale; first four abdominal segments and base of the fifth ferruginous; coxæ and femora, except base of four anterior ones, hind tarsi, and hind tibiæ except bare inner edge, black; remainder of legs honey-yellow, except upper side of trochanters. Wings pale brownish-yellow, infuscated at tips. A rather slender species, with the abdomen elongate, the head distinctly broader than thick and rounded off behind the eyes. Face confluently punctate, with the median depression between the low antennal tubercles extending down to the finely punctate, margined clypeus. Eyes oval, four times as long as the malar space. Antennæ slightly longer than the body; scape twice as long as thick; first flagellar joint distinctly longer than the second; following about quadrate. Parapsidal furrows distinct anteriorly; scutellum with a line of square punctures across its base. Metanotum punctulate on the sides, thinly clothed with thin pale hairs, the lateral groove nearly divided by the oval spiracle. Abdomen sparsely and coarsely punctate except at base and apex. First abdominal segment with its median elevated portion somewhat narrowed and rounded anteriorly, but little narrowed behind, separated from the lateral carina by a coarsely crenulate groove; the segment about as long as broad behind. Second segment rugose-

punctate, the middle field smooth, triangular, short, but prolonged behind as a narrow elevation; on each side with a deep; oblique impression reaching to the posterior angles. Second suture straight medially, curved forward laterally, very broad, crenulate or striate, the anterior angles separated by a lateral, nearly transverse, crenulate groove. Third segment with separated anterior angles and a deep crenulate transverse groove near the base; fourth and fifth segments similarly sculptured, and the sixth obsoletely so. Legs slender. Wings with black stigma; first section of radius one-third as long as the second and two-thirds as long as the first transverse cubitus; second transverse cubitus with a hyaline spot below, slanted outwards above; cubitus not very strongly curved at base; submedian cell as long as the median; recurrent nervure received just before the apex of the first cubital cell; discoidal vein broken a little below the middle.

One female from Camp 39, Madeira-Mamoré R. R., Rio Madeira, Brazil (Mann and Baker).

This does not seem to be very closely related to any other species of similar color.

Iphiaulax starksi sp. nov.

Female. Length 7.5 mm., ovipositor 3 mm. Black, the scutellum and metanotum rufous, first four segments of abdomen, sides and base of fifth, fulvous; four anterior legs beyond the knees, and a stripe on the outer edge of hind tibiæ yellowish; ovipositor fuscous. Wings yellowish hyaline, slightly darkened below the black stigma and infuscated beyond the base of the third cubital cell, veins all fuscous. Head one-third broader than thick, obliquely rounded behind the eyes. Face flattened, finely rugulose, the clypeus with a sharp, raised marginal line. Palpi pale. Antennæ nearly as long as the body; scape almost three times as long as thick; first flagellar joint longer than the second; following quadrate. Mesonotum with the parapsidal furrows distinct anteriorly; scutellum with a crenulate line across the base. Metathorax scarcely punctulate laterally, its spiracles round. Abdomen rather broad. First segment at apex nearly twice as broad as at base, its median elevation oval, much narrowed basally and separated from the lateral carina by a rugose groove. Second segment with a short, broad basal median elevation which is prolonged to the apex as a carina; on each side with a deep oblique depression that marks off the anterior angles, but does not attain the posterior margin. Second suture broad, striate, straight medially and curved forward laterally as the separated angles of the third segment are produced forward; second to fourth segments sparsely, deeply and coarsely punctate. Legs slender. Wings with the first section of the radius nearly one-third as long as the second and two-thirds as long as the first transverse cubitus; second transverse cubitus nearly perpendicular, with a hyaline dot above and below, cubitus bent at the base; recurrent nervure received well before the tip of the first cubital cell; discoidal vein broken a short distance below the middle; submedian cell as long as the median.

One female from Pará, Brazil (Wm. M. Mann) named after Prof. Starks, a member of the expedition.

This species falls near two Brazilian species, *I. hirtulus* and *I. semiflavus* described by Szépligeti, but differs by its much longer ovipositor and different abdominal sculpture.

Iphiaulax carapunæ sp. nov.

Female. Length 9.5 mm.; ovipositor 3 mm. Black, with the apical two joints of the palpi pale yellow and the first four, and base of the fifth abdominal segments bright ferruginous. Wings with a black transverse band beginning at the origin of the basal vein and extending into the base of the radial cell, beyond this infuscated and basally pale yellowish; stigma wholly black; hind wings pale yellowish at base, infuscated on apical half. Head one-half wider than thick, obliquely narrowed behind the eyes. Front impressed on each side above the antennæ and with a median carina that extends down between the short antennal tubercles. Face irregularly rugulose, the small clypeus distinguishable as a smooth spot; malar space short, one-fourth as long as the large, oval eye. Prothorax smooth on the sides, distinctly punctate medially. Mesonotum with smooth, parallel parapsidal furrows that extend to the posterior third. Scutellum convex, with a smooth impressed line across its base. Metanotum evenly rounded, without carinæ; punctulate on the sides. Mesopleura with a deep, oblique femoral furrow; and metapleura with a groove just external to the rounded-oval spiracles. Abdomen one-half broader than the thorax; first segment with an oval elevated portion that is rounded in front. On its sides is a pair of parallel smooth grooves, each separated from a second lateral smooth groove by a strong carina. Second segment with the middle field triangular, reaching beyond the middle of the segment and continued for a short distance as a raised line; sides and anterior angles separated by a very deep depression. Third segment with the basal suture strongly bisinuate and crenulate; the anterior angles separated by very deep impressions; with a triangular middle field that reaches nearly to the middle. Fourth segment with the anterior corners separated and with a transverse groove near the center. This groove is repeated on the fifth segment, and less distinctly on the sixth. Hypopygium shorter than the pygidium. Legs short, stout, and densely hairy, especially the hind pair. Wings with the submedian cell barely longer than the median; recurrent nervure received at the tip of the first cubital cell; first section of radius one-third as long as the second and two-thirds as long as the first transverse cubitus; second transverse cubitus straight, perpendicular; discoidal vein broken at its lower third. Stigma narrowly triangular.

One female, Rio Madeira Brazil (Camp No. 39, Madeira-Mamoré R. R.) (Mann and Baker).

This species resembles *I. polybothris* Brullé, but differs structurally as well as in color.

Iphiaulax abunensis sp. nov.

Female. Length 11.5 mm.; ovipositor 14 mm. Fulvous; the head, except for the pale palpi and the red tip of scape and underside of pedicel; prothorax, except posterior angles; abdomen above, beyond the base of the fifth segment; ovipositor and its sheaths, all coxæ, middle of fore femora, middle femora, except base and apex, hind femora apical half of tibiæ, their tarsi, and apical joint of four anterior tarsi black. Fore wings pale yellowish with an uneven blackish median band and infuscated tips from the base of the third cubital cell; stigma black, hind wings slightly infuscated. Head transverse, not quite half broader than thick; antennæ slightly shorter than the body, the scape twice as long as thick; first two flagellar joints subequal, each twice as long as thick. Face sparsely and irregularly punctate on the sides, with a median flat, polished area showing traces of fine aciculations; clypeus finely irregularly punctate; antennal tubercles short. Eyes oval, three times as long as the malar space. Mesonotum with the parapsidal furrows indicated only in front. Scutellum with a crenulate line across its base. Metanotum smooth above, punctulate on the sides, with a deeply impressed groove just outside the elongate oval spiracles. First segment of abdomen, exclusive of its membranous sides, twice as long as wide, the lateral margins parallel; the median elevation ovate, pointed in front, constricted and truncate behind; on each side of this is a deep, narrow, groove before the carinate margin. Second segment nearly as long as wide behind, the median field long and narrow, reaching beyond the apical third of the segment; on each side of this is a broad longitudinal depression, then a carina, then a second similar, but narrower depression that extends to the posterior corner. Second suture rather wide, obsoletely crenulate, slightly extended forward at the middle where the apical margin of the second segment is raised. Third segment the widest; twice as broad as long and faintly concave on its posterior margin; the anterior angles not produced forward, but separated as large spaces by a groove that curves across the segment from near the median line to the center of the lateral margin; with an indistinct, narrowly triangular median elevation. Fourth segment with an arcuate groove, interrupted at the median line, across the middle of its base. Legs rather long, not stout, wings with the cubitus strongly bent near the base; recurrent nervure received at the tip of the first cubital cell; first section of the radius one-third as long as the second and two-thirds as long as the slightly oblique second transverse cubitus; submedian cell slightly, but distinctly, longer than the median; discoidal vein broken near its lower third.

One female from Abuná, Rio Madeira, Brazil (Mann and Baker).

This is related to *I. excisus* Szépligeti, but differs by its shorter ovipositor and different abdominal sculpture, the second segment having two pairs of longitudinal grooves, and the fourth having an arcuate line, without lateral curved lines.

Subfamily RHOGADINÆ

Rhogas Nees.

There are two species, both undescribed, in the collection, which brings up the total of Brazilian species to five. These may be distinguished as follows:

1. Recurrent nervure inserted in the first cubital cell.....2
   Recurrent nervure interstitial or nearly so.....4
2. Wings of uniform color.....3
   Wings distinctly bifasciate.....*R. bakeri* sp. nov.
3. Pale yellow, with head, antennæ and four hind legs beyond the knees deep black .....*R. insignipes* sp. nov.
   Yellowish red, with abdomen blackened above; all legs pale beyond the knees.....*R. braziliensis* Szép.
4. Legs entirely pale, wings distinctly bifasciate.....*R. maculipennis* Szép.
   Hind femora mostly black; wings very indistinctly maculate.....*R. pulchricornis* Szép.

Rhogas insignipes sp. nov.

Male. Length 8 mm. Uniformly pale ochre-yellow, very conspicuously and sharply marked with black as follows; entire antennæ and head, except palpi; last joint of fore tarsi; middle legs beyond the basal third of the tibia, and hind legs beyond the extreme base of the tibia. Wings tinged strongly with yellowish-fuscous; veins pale brown; stigma wholly piceous; pale parts of body with pale yellow pubescence; black parts with black. Head somewhat over twice as broad as thick antero-posteriorly, the front occupying only one-fourth the width of the head when seen from above. Face of the same width as the front, transversely rugose aciculate, with a short, sharp keel below the antennæ. Eyes very large, deeply emarginate opposite the antennæ; malar space extremely short, only half as long as one of the middle joints of the antennæ. Ocelli very large, the lateral ones nearly touching the eye-margin, due to the narrowness of the front. Antennæ as long as the body, about 65-jointed, gradually tapering, the joints about quadrate. Head behind the eyes microscopically rugulose. Mesothorax dull, but not punctate, the parapsidal furrows sharply defined but not at all crenulated. Scutellum with a broad, deep, longitudinally fluted and medially divided depression across its base, dull like the mesonotum; post-scutellum paler and polished. Metathorax with the median and lateral carina complete, though delicate, the former bifurcating behind to form a very small petiolar area; surface of metanotum faintly roughened. Pleuræ smooth and polished. Abdomen with the median carina distinct on the first two segments, but without any distinct longitudinal aciculation; first segment one half longer than wide at tip; base two-thirds as wide as tip; second segment slightly transverse; following becoming more strongly so. Legs moderately slender. Wings ample; stigma lanceolate, emitting the radius at its middle; first section of radius two-thirds as long as the second; recurrent nervure received at half its own length before the tip of the first cubital cell; transverse median nervure entering the first discoidal cell before the middle.

One specimen from Independencia, Parahyba, Brazil (Mann and Heath).

The conspicuously blackened legs of this species render it very conspicuous and easily recognizable.

Rhogas bakeri sp. nov.

Female. Length 6 mm. Very pale luteous, with the stemmaticum black, and the hind femora, tip of their tibiæ and tips of all tarsi slightly infuscated. Wings pale yellow, with a basal cross-band of fuscous which is more or less separated into two spots, one on the basal vein and the other below the apical part of the submedian cell. Veins and stigma pale luteous, fuscous along the clouded parts of the wing. Head twice as broad as thick antero-posteriorly, the narrowest part of the front one-third as broad as the head, face faintly rugulose, with a short carina below the antennæ. Antennæ (broken at tips) probably about 40-jointed, the joints quadrate. Eyes large, emarginate opposite the antennæ, but not very deeply so; malar space as long as the basal joint of the antennal flagellum. Ocelli large, the posterior ones as far from the eye-margin as from one another. Head punctulate behind the eyes. Mesonotum dull, with the parapsidal furrows present, but very weakly impressed. Scutellum with the basal impression coarsely striated, not divided by a median carina. Metanotum rugulose, with a median and lateral carinæ, weakly elevated. Pleuræ impunctate, the mesopleura larger and extending farther downward than usual. Abdomen with the median carina extending to the middle of the third segment; first and second segments very faintly longitudinally aciculated; first segment one-third longer than broad at tip, its base two-thirds as wide as the tip; second segment slightly longer than broad; third transverse, following much shorter, ovipositor nearly one-third as long as the second abdominal segment. Legs stout, the femora thickened, especially those of the hind pair. Wings with the stigma rather broad, its width nearly equal to the length of the first section of the radius which is fully as long as the second; recurrent nervure received more than half its own length before the tip of the first cubital cell; second cubital cell almost as high at apex as at base, the second transverse cubitus hyaline except at the corners of the cell; transverse median vein entering the first discoidal at its middle.

One female from Rio Madeira (Camp No. 39, Madeira-Mamoré R. R.) Brazil, Mann and Baker.

This is a rather anomalous species, showing somewhat of a transition to *Heterogamus* in the length of the first section of the radial vein. It is quite similar to the West Indian, *R. bifasciatus* Ashm., but the abdominal carina extends beyond the first segment.

Eucystomastax gen. nov.

Related to *Cystomastax* Szépligeti which it resembles in the peculiarly swollen palpi, but differing in the broadly sessile abdomen, longer submedian cell, smaller eyes, round metathoracic spiracles, etc.

Resembling *Rhogas* in general habitus. Head transverse, narrowed behind the eyes; margined behind. Malar space as long as the mandible; eyes moderately emarginate opposite the antennæ. Maxillary palpi 5-jointed, with the first to third joints greatly swollen, but not flattened; labial palpi 3-jointed, first joint thickened, but cylindrical. Clypeus sharply projecting, with a porrect mystax of stiff black hairs. Ocelli moderately large and close together. Antennæ setaceous, a little longer than the body. Thorax with the parapsidal furrows deep anteriorly, but abbreviated behind. Metathorax with a complete median and lateral carinæ; its spiracles rather small, round; mesopleural suture complete, crenulated. Abdomen with a strong median carina on the first two segments; a little longer than the head and thorax; coarsely longitudinally aciculated on the first, second and base of third segment; first segment one-third longer than the second, less than twice as long as broad at tip; second segment slightly transverse; third twice as broad as long; fourth to seventh strongly transverse; all the sutures very deeply impressed. Legs long, rather slender, densely hairy. Wing with the marginal cell nearly reaching to the tip, stigma lanceolate, radius originating just before its middle; first section of radius one-third as long as the second; second transverse cubitus not swollen; not so stout as the other veins; recurrent nervure at the apical fourth of the first cubital cell; transverse median vein inserted beyond the basal third of the first discoidal cell; discoidal vein broken far below the middle. Hind wing with the submedian cell half as long as the median.

Type. *E. bicolor* sp. nov.

This genus may be separated from the related genera of Rhogadinæ having dilated palpi as follows:

1. Palpi with the joints in part flattened, leaf-like.....2
   Palpi with the joints swollen, but not flattened.....3
2. Second section of radius twice as long as the first; upper and lower sides of second cubital cell parallel.....*Macrostomion* Szep.
   Second section of radius less than twice as long as the first; second cubital cell distinctly narrowed toward its tip.....*Pelecystoma* Wesm.
3. Metathoracic spiracles round; abdomen sessile....*Eucystomastax* gen. nov.
   Metathoracic spiracles slit-like; abdomen petiolate.....*Cystomastax* Szep.

Eucystomastax bicolor sp. nov.

Male. Length 9.5 mm. Black, with the base of the mandibles, fore coxæ, and entire thorax except tip of metathorax, orange-yellow. Head twice as broad as thick, strongly convex below the antennæ; the face with a short median carina just below the antennæ; front smooth and shining, slightly concave; vertex and cheeks smooth; hind head punctulate; face smooth below on sides; elsewhere microscopically rugulose-punctulate. Mandibles with the upper tooth twice as large as

the lower one. Antennæ 68-jointed, slender, longer than the body, the flagellar joints all about twice as long as thick; the first three times; scape oval, twice as long as thick. Prothorax smooth and shining, deeply impressed across each side. Mesonotum smooth, strongly elevated, especially the middle lobe in front; the parapsidal furrows not sharp, but more or less indicated in front by broad impressions. Scutellum triangular, margined only at the sides of the basal impression; its disc with a few large punctures. Metanotum smooth medially in front, on the sides punctate and behind irregularly rugose. Pleuræ smooth, with a few punctures only on the metapleuræ. Abdomen highly polished, smooth beyond the base of the third segment. Legs long and thickly hairy on the tibiæ and tarsi. Wings deeply infuscated, nearly black, but with very little violaceous reflection; veins black, piceous beyond the cross-veins.

One male. Pará, Brazil. Mr. Wm. M. Mann.

This is a very conspicuous species on account of its brightly contrasting thorax, black wings and polished body.

Subfamily SPATHIINÆ

Heterospilus fasciiventris sp. nov.

Female. Length 2.2 mm.; ovipositor 0.7 mm. Meso- and meta thorax, first segment and posterior third of second segment of abdomen black; head dilute piceous, black above. Scape, base of antennæ, ovipositor and legs pale yellow. Abdomen, except for the black markings, pale honey-yellow. Extreme tips of tarsi and ovipositor black. Head twice as broad as thick, moderately narrowed behind the eyes and somewhat excavated behind; strongly margined behind. Vertex shining; feebly, but distinctly transversely aciculate; with a circular impression to the side of each posterior ocellus, the two narrowly connected above the ocelli; posterior ocelli nearly as far from each other as from the eye margin; front slightly concave, weakly transversely aciculate, the lateral margin slightly carinate just above the antennæ. Antennæ long and slender, basal flagellar joint six times as long as thick; the joints near the middle of the flagellum four times as long as thick. Face honey-yellow, rugulose, clypeus honey-yellow, very convex. Mesonotum shagreened, with deep, convergent crenulate parapsidal furrows; middle lobe aciculate behind as in the following species. Scutellum shagreened, with a broad, deep longitudinally fluted groove across its base. Metathorax partly areolated; its upper face with a lateral carina, and the sides of a posterior carina, enclosing a large rugulose area which is angularly excavated behind by a large diamond-shaped supero-median area that is open behind at the apex of the metathorax and closed near the base; surface except on the basal area coarsely rugose-reticulate. Pro- and mesopleuræ shagreened, the former with a deep, oblique groove, the latter with a deep groove along its lower margin, several oblique foveate impressions at its anterior angle and with a crenate line along its posterior edge. Metanotum rugose-reticulate, with a minute thorn-like projection just above the middle

coxa. Abdomen as long as the head and thorax together; ovate-lanceolate; first segment twice as long as broad at tip, with a somewhat raised median space bounded by carinæ converging from the anterior angles, but not very clearly differentiated from the irregular longitudinal aciculations which cover the segment. Second segment nearly as long as broad at tip; aciculated on its basal two-thirds; crossed just before the middle by a crenulate impressed line, and at its posterior third by a broad, shallow groove; third to sixth segments smooth and shining. Legs scarcely thickened, sparsely beset with pale hairs. Wings subhyaline; stigma and veins dilute fuscous; the former, very narrowly triangular, emitting the radius somewhat before the middle; first section of radius two-thirds as long as the second; cubitus arising a little above the middle of the basal vein; first transverse cubitus wanting, second weak, but distinct; submedian cell a little longer than the median, the transverse median vein very short, almost punctiform; subdiscoidal vein interstitial, the second discoidal cell wide open.

One female from Ceará-Mirim, Rio Grande do Norte, Brazil. (Wm. M. Mann).

This species is much more slender and structurally quite different from the following, and when these small Braconidæ are better known the two will probably fall into different genera.

Heterospilus meridionalis sp. nov.

Female. Length 2.6 mm.; ovipositor 1.5 mm. Black; apical half of antennæ and abdomen beyond the second segment piceous; scape and base of antennal flagellum castaneous; palpi whitish; coxæ pale yellow; tegulæ and legs dull brownish yellow. Wings slightly infuscated, with dark brown stigma and veins. Head shagreened above, rugulose on the face; barely twice as wide as thick and sharply narrowed behind the eyes; with a strong margin behind. Front concave above the antennæ, but not deeply impressed; ocelli in a triangle with its shortest side above, the posterior ones nearly twice as far from the eye as from one another. Face evenly convex, piceous, with a small raised smooth spot below the antennæ; clypeus dull yellow, semicircular, with the arcuate upper margin indicated by a fine raised line. Cheeks smooth and polished, malar space about one-third as long as the nearly circular eye. Antennæ 25-jointed, very slender; scape subcylindrical, twice as long as thick; pedicel quadrate; first flagellar joint four times as long as thick; following gradually shortening, those near the middle of the flagellum three times as broad as thick. Thorax finely shagreened, with a faint æneous tinge; parapsidal furrows deep and crenulate; middle lobe of mesonotum with three short, deep longitudinal grooves before the base of the scutellum. Scutellum with a broad, deep, longitudinally fluted groove across its base. Metathorax rugose-reticulate, with a rather ill-defined area on each side at the base; these areas much more finely sculptured except around the border. Propleuræ

with a broad horizontal, crenulate furrow, rugulose anteriorly and rugose-reticulate behind; mesopleura shagreened, with an arcuate crenate groove near the upper anterior angle and a similar one along its posterior edge. Abdomen as long as the head and thorax, curved downwards and obovate when seen from above; sessile, the first segment as long as broad at tip, the base somewhat over twice as broad as the apex. First and basal two-thirds of second segment longitudinally aciculate, the striæ becoming finer apically; beyond to the apex smooth and shining, with broad rufous margins on the second to fifth segments; sixth entirely castaneous. Second segment with a fine impressed line across its middle and traces medially of a second groove just behind this line. Legs slightly thickened on the femora; sparsely pilose with pale hairs. Wings subhyaline, the stigma narrowly triangular, emitting the radius at its center; cubitus arising near the top of the basal vein, first transverse cubitus barely discernible, interstitial with the recurrent nervure; second one weak, but distinct; first section of the radius three-fourths as long as the second; submedian cell slightly longer than the median; subdiscoidal vein interstitial, the second discoidal cell wide open. Hind wing with a closed basal cell, but without a radius. Ovipositor as long as the abdomen, fulvous, black at tip; its sheaths piceous.

One female from Ceará-Mirim, Rio Grande do Norte, Brazil, collected by Mr. Wm. M. Mann.

This species approaches *H. nigrescens* Ashm. from the Island of St. Vincent, but has no white ring at the base of the antennæ, and the ovipositor is twice as long.

Heterospilus dubitatus sp. nov.

Female. Length 2 mm., ovipositor 0.6 mm. Piceous, varied with rufous; legs testaceous, wings subhyaline. Antennæ with the scape yellow, except at tip; flagellum piceous, fuscous toward the base; palpi whitish; collar, mesonotum and mesopleura black; remainder of thorax rufous; abdomen black beyond the transverse groove on the second segment; rufous basally; ovipositor yellow, with black tip; legs pale testaceous, blackened on the tips of the tarsi.

Resembles *H. meridionalis* very closely in structure, but the antennæ are 23-jointed, the triangular area on each side of the metathorax at base is sharply defined, and not at all sculptured, except for a row of punctures around its edge, the first abdominal segment has a very distinct elevated median portion defined by a pair of carinæ that converge somewhat from the anterior angles to near the tip of the segment; the second segment bears two complete, approximate transverse furrows near the middle, this segment being considerably longer than wide instead of quadrate; and the first section of the radial vein is fully as long as the second.

One female from Ceará-Mirim, Rio Grande do Norte, Brazil. (W. M. Mann).

The three species of *Heterospilus* here described may be distinguished as follows:

1. First segment of abdomen as long as broad at tip; abdomen conspicuously banded with yellow.....*H. fasciiventris*
   First segment distinctly shorter then broad at tip; abdomen black, more or less rufous at base.....2
2. Ovipositor as long as the abdomen; first section of the radius much shorter than the second; abdomen black.....*H. meridionalis*
   Ovipositor scarcely more than one-half as long as the abdomen; first section of the radius as long as the second; abdomen rufous on the first segment and basal half of the second.....*H. dubitatus*

Family ALYSIIDÆ

Idiasta nigripennis sp. nov.

Male. Length 5.5–6 mm. Black, with the thorax and basal half of the abdomen honey-yellow; wings very strongly infuscated, almost black. Head large, highly polished, a little more than twice as broad as long, not narrowed behind the eyes. Clypeus very small, sharply triangular, closely punctate, face punctulate; front smooth and highly polished with a deep transverse depression above the antennæ and below the ocelli which occupy a small triangle far from the eyes; antennæ long, one-half longer than the body; with fifty joints. The fourth very distinctly longer than the third. Mandibles fuscous, with black teeth, coarsely punctate externally. Palpi very delicate and slender, pale yellow. Eyes almost circular, their diameter equalling the length of the fourth antennal joint. Mesonotum smooth and polished, with deep strongly convergent parapsidal furrows which unite far before the scutellum. Scutellum strongly convex medially in front, straight on its posterior edge, and at the base with a broad deep depression separating it from the mesonotum. This groove is divided on the median line by a fine carina. Pleuræ smooth and shining, the mesopleura deeply impressed just below the wing and with a foveate impression just before the carina which separates it from the metapleura. Metathorax smooth, with a strong median carina that bifurcates behind to form a broad triangular petiolar area; also with a lateral, strongly sinuate carina that curves laterally to go out beyond the moderately small, circular spiracle. Metapleura with a large deep foveate impression just anterior to the spiracle and a smaller one below, near the middle, just behind the anterior margin. Abdomen broadly sessile, peculiarly formed at the base in that the ventral part of the first segment spreads out laterally beyond the dorsal part; seen from above it is exposed behind on each side to a width of nearly one half the dorsal plate. The latter is less than twice as long as broad at the tip which is twice as wide as the base; spiracles at the middle, very prominent, their tips as far apart as the posterior angles; petiole at base with two short, convergent carinæ. Abdomen smooth and shining, but little widened medially and one-half longer than the head and thorax together; black above beyond the second segment. Legs slender, loosely hairy; entirely black, except for yellowish tips to the trochanters, bases to the tibiæ and a fuscous tinge on the tarsi and anterior tibiæ. Wings blackened,

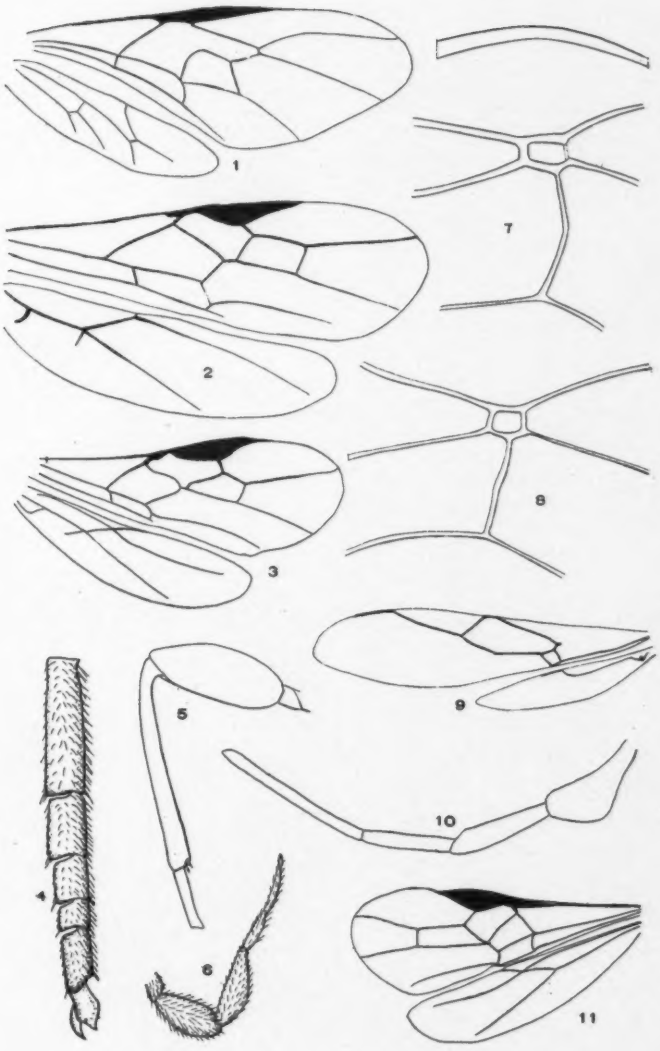
piceous with black stigma and veins. Stigma lanceolate, the radius arising at its posterior third; half as broad as the radial cell; second section of radius twice as long as the first. First section of cubitus sinuate, the recurrent nervure received distinctly before the tip of the first cubital cell; submedian cell considerably longer than the median; subdiscoidal nervure arising below the middle of the discoidal vein, although in position it lies far forward, due to the upper section of the discoidal vein being nearly parallel to the axis of the wing. Hind wing with the radius and subdiscoidal vein well developed.

Four specimens, showing practically no variation, from Abuná, Rio Madeira, Brazil.

This is the first species of *Idiasta* to be described from the neotropical region.

EXPLANATION OF PLATE.

Fig. 1. *Ophiogastrella maculithorax* sp. nov., wings.
Fig. 2. *Eucystomastax bicolor* gen. et sp. nov., wings.
Fig. 3. *Idiasta nigripennis* sp. nov., wings.
Fig. 4. *Bracon crassitarsis* sp. nov., fore tarsus.
Fig. 5. *Parabinarea manni* gen. et sp. nov., hind leg.
Fig. 6. *Eucystomastax bicolor* gen. et sp. nov., maxillary palpus.
Fig. 7. *Mesostenoideus crassus* sp. nov., portion of fore wing.
Fig. 8. *Cryptus heathi* sp. nov., portion of fore wing.
Fig. 9. *Ophionellus manni* sp. nov., wings.
Fig. 10. *Megaplectes branneri* sp. nov., maxillary palpus.
Fig. 11. *Bracon paraënsis* sp. nov., wings.



C. T. Brues.

THE LACINIA IN THE MAXILLA OF THE HYMENOPTERA.*

By Alex. D. MacGillivray,
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The maxilla of biting insects consists of six pieces. There is at the proximal end a two segmented cardo (*c*), which articulates the maxilla to the head capsule (Figs. 1 and 2†). Attached to the distal end of the cardo there is in the cockroach (Fig. 1) a rhomboidal-shaped piece, the stipes (*s*). The stipes in the locust (Fig. 2) is also rhomboidal in outline but is limited in its articulation to the mesal portion of the cardo. There is borne at the distal end of the stipes in the cockroach a two-segmented, somewhat bent tongue-shaped piece, the galea, (*g*). The galea of the locust is also two-segmented but borne at the distal and lateral margin of the stipes. At the proximal end of the galea against the lateral margin of the stipes, there is a small sclerite, the palpifer (*p*), which bears the five segmented maxillary palpus. The proximal segment of the galea and the palpifer in the locust constitute the lateral margin of the stipes. There is borne at the distal end of the stipes on the mesal side another appendage, which bears three prominent teeth at its distal end. This is the lacinia (*la*). The arrangement of the parts in the maxillæ of biting insects is for all practical purposes identical with the above description and the figures of the maxillæ of the cockroach and the locust, showing two distal pieces, a lacinia on the mesal side and a galea on the lateral side, with a segmented maxillary palpus attached on or near the lateral margin at the proximal end of the galea, and is characteristic.

If the maxilla of *Macroxyela infuscata* (Fig. 3), one of the most generalized members of the order Hymenoptera, a tenthredinid, known to me, is compared with that of the cockroach

*Contribution from the Entomological Laboratories of the University of Illinois, No. 29.

†The cardo of *Melanoplus differentialis* as here figured shows a narrow proximal piece with two projections at its proximal end; the shorter piece articulates against the ectal surface of the head capsule and the larger piece passes beneath the margin of the head capsule and serves for the attachment of muscles. These pieces are characteristic of this and some other species. It has been overlooked because it usually remains attached to the head capsule when the maxilla is removed.

or locust, a somewhat similar condition is found. The cardo, however, consists of a single piece which bears at its distal end an irregular-shaped stipes. The stipes bears at its distal end on the mesal side a quadrangular-shaped sclerite, which from its position must be the lacinia. There is borne on the lateral part of the distal portion of the stipes a two-lobed piece, the galea, which consists of a larger outer and a smaller inner lobe. The suture dividing the galea into two pieces is obsolete. Although not demonstrable, it is quite likely that the small mesal lobe of the galea is derived from the proximal sclerite of the galea and the large lateral lobe from the distal sclerite of the galea. The palpifer and maxillary palpus occupy corresponding positions to these sclerites in the cockroach. The maxilla of *Macroxyela* is short and broad and retains many of the general features and appearances of the maxillæ of the cockroach and locust.

The maxilla of *Dolerus unicolor* (Fig. 4), another tenthredinid, differs from that of *Macroxyela* in that it shows some of the tendencies so characteristic of the maxillæ of the higher Hymenoptera, an elongation and narrowing of the parts. This is especially marked in the cardo of *Dolerus*. The maxilla of *Dolerus* also has three lobes at the distal end. The rounded setaceous lateral portion is the homologue of the large lateral lobe of the galea of *Macroxyela*, while the mesal and proximal rounded lobe is the homologue of the small mesal lobe of the galea of *Macroxyela*. The lacinia is a long, pointed lobe projecting beyond the mesal lobe of the galea but attached to the stipes beneath this lobe of the galea. *Dolerus* is a comparatively generalized tenthredinid yet it shows an early stage in the migration of the lacinia from the distal end of the maxilla. A somewhat similar condition is shown in the maxilla of an ichneumonid, *Ophion bilineatum* (Fig. 5). The two lobes of the galea are large, the mesal lobe is a broad flat plate and almost completely covers the lacinia, which is a broad lobe attached to the side of the stipes. The lateral lobe of the galea is elongated and terminal as in the higher Hymenoptera.

In the white faced hornet, *Vespa maculata* (Fig. 6), the maxilla shows a decided elongation of all the parts, the cardo, stipes, and lateral lobe of the galea. The sclerites are not all arranged in the same plane as with the maxillæ previously described. This is due to the fact that the maxillæ are closely appressed to the sides of the convex labium or lower lip, which

has changed somewhat the orientation of the parts. The galea is almost as long as the elongated stipes and is composed for the most part of a large lobe which is the homologue of the lateral lobe of the galea of the maxillæ previously described. The homologue of the mesal lobe is much smaller and has changed its position somewhat. It is a small lobe placed on the surface of the larger, lateral lobe, nearer its lateral than its mesal margin. The mesal margin of the small, mesal lobe is marked by a row of long setæ. All the sutures between the parts of the galea and the stipes are obsolete. There are several dark and light areas with oblique ridges where they probably fuse, but specimens prepared with caustic potash show no indication of a suture in this region. The lacinia is a small but well marked lobe attached to the mesal margin of the proximal end of the stipes. Its position is clearly indicated in figure 6. The distal end of the lacinia is usually folded under the proximal end of the galea and more or less concealed. It shows distinctly on unmounted specimens studied in alcohol.

A thread-waisted wasp, *Sphex pennsylvanicus* (Fig. 7), shows a somewhat different condition. In the maxilla of this insect the small, mesal lobe of the galea is wanting and the lateral lobe developed into a greatly elongated, blunt piece, which projects for some distance beyond the stipes and is almost as long as the maxillary palpus. There is a groove along the lateral margin of the galea that may mark the line of separation of the small, mesal lobe of the galea. Unfortunately it was not discovered until it was too late to remedy the defect, that the figure of this maxilla was turned in the oppsite direction from the others. The lacinia is located at the proximal end of the galea in this maxilla. It is a broadly rounded lobe. Its location and the development of the proximal end of the galea as an overhanging projection would suggest that the lacinia had been modified into a supporting piece.

The greatest modification of the maxillæ is found with the bees where they have been greatly elongated into plates for close appression against the labium for the formation of a tube. The maxilla of a bumble bee, *Bombus terricola* (Fig. 8), shows this condition well. The galea is a sword-shaped blade as long as the remainder of the maxilla. It is attached to the distal end of the stipes. The two are fused without any indication of a suture. There is an oblique ridge marking the edge of a deep

furrow with lighter intervening parts. It is likely that this oblique, clear area distad of the ridge marks the distal limit of the stipes. This would make the union between the stipes and galea an oblique one with the maxillary palpus attached to the distal prolongation of the stipes. A similar condition will be noted in the other maxillæ figured. The furrow extending across the maxilla is the limit of the distal part of the maxilla that is folded under the labium. If this ridge be considered as the suture between the stipes and the galea, it would place the maxillary palpus on the galea, which is an impossible interpretation in the light of the other maxillæ studied. In the more specialized Hymenoptera, wasps and bees, there is a cuticular membrane connecting the maxilla and the labium, which serves to close the mouth cavity on the ventral side. The distal edge of this membrane is attached to the stipes near the proximal end of the lacinia. This membrane is particularly well marked in mounts of the entire maxilla and labium of *Bombus*. In such mounts, the lacinia can be identified as a round lobe with long setæ on its distal and lateral margins. It is placed adjacent to the distal margin of the membrane extending from the maxilla to the labium and is attached to the mesal margin of the stipes near its distal end or to the uncolored area of the stipes. This lobe is so distinct, once it has been seen, it is hard to understand how it has remained undescribed for so long. The lacinia, while showing distinctly in specimens mounted in balsam, can be studied to better advantage on maxillæ that have been cleared in caustic potash and examined in a watch glass in alcohol.

Insect morphologists have been fairly uniform in their statements regarding the lacinia in the honey bee, *Apis mellifica* (Fig. 9). All the more important text-books on entomology figure a maxilla of *Bombus* or *Apis*, but without indication of the lacinia. The following quotations are typical for the maxilla of *Apis*. Comstock and Kellogg* describe these parts as follows:

"*Stipes*. The stipes is an irregular, elongate sclerite, strongly chitinized. Its proximal end is bluntly rounded and swollen. The stipes articulates with the proximal segment of the galea (see below) by a diagonal face.

*Comstock, John Henry and Kellogg, Vernon L. The elements of insect anatomy. Ithaca. 1901. Pp. 78–79.

"*Galea.* The *galea* (we incline to believe this part homologous with the galea of the locust's maxilla, rather than with the lacinia, because of its two-segmented condition) extends distad from the stipes as a tapering blade-shaped piece. It is composed of two segments. The proximal one is small and triangular, articulating by the entire length of one of its margins with the stipes. The distal segment or sclerite constitutes the real blade-like portion of the maxilla, and nearly equals in length the ligula and labial palpi (see below). Its surface is unequally divided into two portions by a submedian, dark-brown, longitudinal line. (This line may indicate a coalescence of galea and lacinia into this one blade-like compound sclerite). This line bears several hairs, and there are scattering hairs elsewhere on the sclerite, especially toward the distal end."

Snodgrass† writes as follows of the maxilla of the honey-bee:

"Let us now return to a study of figure 15D. The series of lateral pieces as already explained are the maxillæ. A comparison with figure 3B representing a generalized maxilla will show that these organs in the bee have suffered a greater modification than has the labium, but the parts can yet be quite easily made out. The main basal plate (*st*) is the combined *stipes*, *subgalea*, and *palpifer*, the basal stalk is the *cardo* (*cd*), and the little peg-like process (*mx plp*) at the outer end of the stipes is the greatly reduced *maxillary palpus*. Hence, we have left only the terminal blade-like lobe (*mx*) to account for, and it is evident it must be either the galea or the lacinia (See fig. 3B, *ga* and *lc*) or these two lobes combined. Here again a comparative knowledge of the mouth parts of Hymenoptera comes to our aid and shows clearly that the part in question is the outer lobe or galea, for the inner one becomes smaller and smaller in the higher members of the order and finally disappears."

There is expressed in these two quotations very different views, the former that the galea and lacinia are probably coalesced and the latter that the lacinia is wanting. This is the status of the lacinia in the higher Hymenoptera, writers consider it either as fused with the galea or as obsolete.

A comparison of the drawing of the maxilla of the honey bee with that of *Bombus* shows it to be similar in form but shorter and consists of a long, slender, proximal piece, the cardo,

†Snodgrass, R. E.—The anatomy of the honey bee. U. S. Dept. Agr., Bur. Entom., Tech. Ser. No. 18. 1910. Pp. 45–46.

and a distal piece divided into two regions by the difference in coloration. The distal two-thirds is a blade-shaped piece with a median ridge bearing setæ. This blade-shaped piece is the galea and the median ridge is the supposed line of coalescence of the galea and lacinia of Comstock and Kellogg. There is borne on the lateral margin at the proximal end of the galea a two-segmented appendage, the palpifer and a one-segmented maxillary palpus. The palpifer is inserted in a furrow in the side of the maxilla and can be pushed back against the bottom of this furrow so as not to project beyond the lateral margin of the maxilla. There is a distinct convexity at the distal end of this furrow and an oblique line extends across the maxilla from this point, which probably marks the division between the galea and the proximal piece of this portion of the maxilla, the stipes. The suture between the galea and stipes is obsolete. The lacinia is a thin, cuticular lobe attached near the mesal margin of the stipes at its distal end. It is not attached at the margin of the stipes but a short distance within. The lacinia at its distal margin is developed into a lobe which rests upon the base of the galea. It is so delicate that where it rests upon the galea, its distal end appears like a faint, curved, transverse suture. The distal end of the lacinia resting upon the galea is evidently what Comstock and Kellogg have mistaken for a suture separating the galea into a triangular proximal piece and a distal blade-like piece. The lacinia is larger and more distinct in the honey bee than in *Bombus*. It shows very distinctly on specimens cleared in caustic potash and studied in alcohol.

The lacinia was found to be present in the maxillæ of practically all the Hymenoptera examined. It is very large and distinct in *Priocnemis*, fully one-third the size of the galea which is greatly expanded and consists of two distal lobes. In the large carpenter ant, *Campanotus*, the lacinia is a distinct lobe at the proximal end of the galea. Wheeler* considers it as present but his figures of the maxillæ copied from Janet do not show it. A species of *Andrena* also shows it as a lobe similar in form and location to that of *Bombus* and *Apis* but smaller. The only hymenopterous insect examined where the lacinia was found to be completely wanting was the short tongued bee,

*Wheeler, W. M.—Ants, their structure, development, and behavior. New York. 1910. P. 19.

Augochlora. In this bee the galea has been reduced to a mere oblique knob at the distal end of the maxilla and the stipes transformed into a blade-shaped organ with a distinct palpifer and a five segmented maxillary palpus on the lateral margin near the distal end of the maxilla.

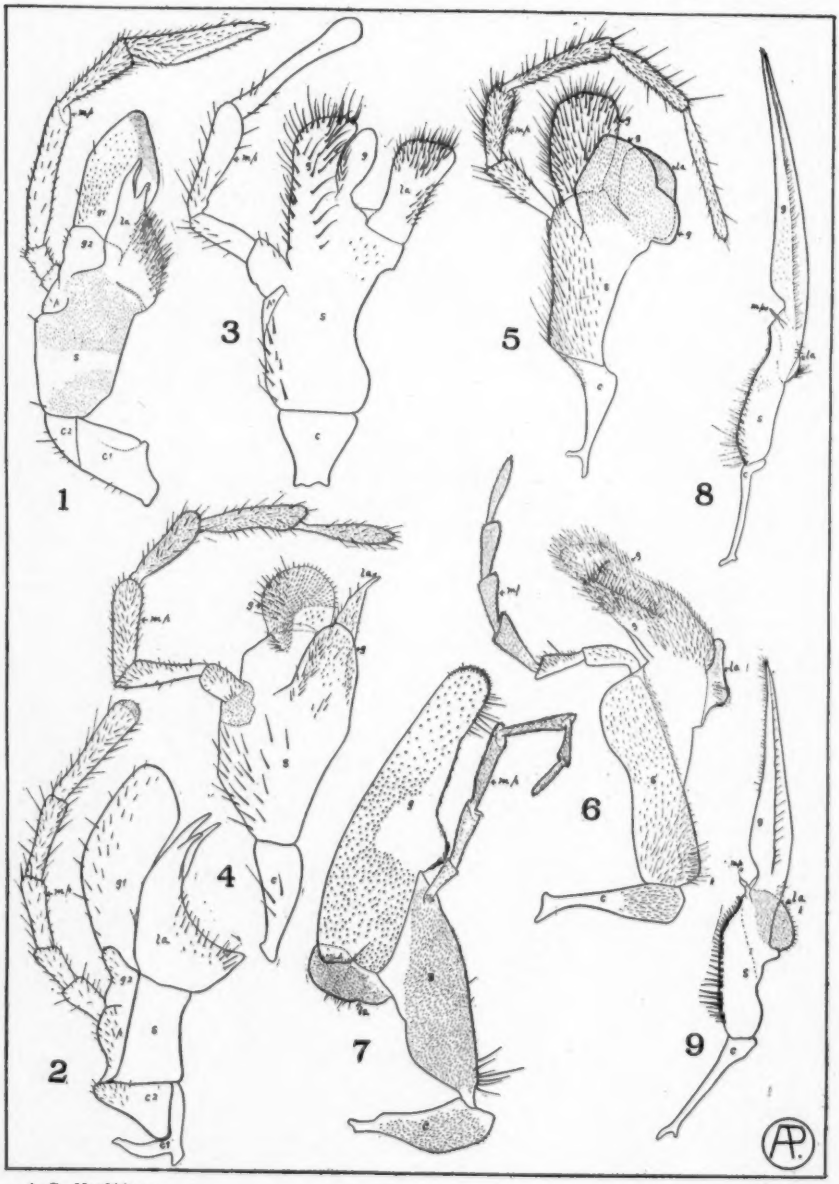
LIST OF ABBREVIATIONS.

c. Cardo.
c1. Proximal segment of cardo.
c2. Distal segment of cardo.
g. Galea.
g1. Distal segment of galea.
g2. Proximal segment of galea.
la. Lacinia.
mp. Maxillary palpus.
p. Palpifer.
s. Stipes.

PLATE XVIII.

(Drawings by Alvah Peterson.)

1. Periplaneta orientalis.
2. Melanoplus differentialis.
3. Macroxyela infuscata.
4. Dolerus unicolor.
5. Ophion bilineatum.
6. Vespa maculata.
7. Sphex pennsylvanicus.
8. Bombus terricola.
9. Apis mellifica.



A. D. MacGillivray.

THE PUPAL WINGS OF HEPIALUS THULE.

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The adult wings of the different species of the genus *Hepialus* are of particular interest because they show such a generalized condition. They approximate the closest to the hypothetical wing type of Comstock and Needham of any insect's wings with which I am acquainted. This hypothetical type is supposed to show the number and arrangement of the longitudinal veins as they existed in the primitive insect's wing. These authors have shown that a study of the arrangement of the tracheæ preceding the formation of the veins in developing wings throws much light on the homology of the veins of the adult wing. Many developing wings of Lepidoptera have been studied and figured, but so far as I am aware no investigator has studied and figured the developing wing veins of a species of *Hepialus*. It was my good fortune, through the kindness of Professor J. M. Swaine of MacDonald College, Quebec, Canada, to obtain pupæ of *Hepialus thule* hardened in formol in the right stage for a study of the developing wing veins. These specimens showed not only the tracheæ, which are represented as black lines on the accompanying figure, but also the veins, which are represented as white bands. Unfortunately nothing could be determined as to the arrangement of the tracheæ after they left the veins and entered the body. The various veins will be taken up in order.

Costa.—The costa can be traced as a distinct, unbranched vein in both wings a short distance within the costal margin. A trachea was found only in the costa of the front wings and this was only a mere stub.

Subcosta.—The subcosta shows as a two-branched vein, identical in form with the subcosta of the hypothetical type. The tracheal stem of subcosta is distinct and in the front wing branched midway between the base of the wing and the point of separation of subcosta into Sc_1 and Sc_2, though in the hind wings the point of branching of the trachea is much nearer the point of separation of the two branches of subcosta. The

*Contribution from the Entomological Laboratories of the University of Illinois, No. 30.

tracheal branch supplying Sc_1 is much weaker than that extending through Sc_2. The preservation of both branches of subcosta is peculiar to the Jugatæ among the Lepidoptera. In the Hepialidæ, this condition differs with the different species; in some species they are both well preserved, in others the portion representing the free part of Sc_1 is sometimes present in both wings, sometimes present in the front wing and wanting in the hind wing or *vice versa*, or it may be entirely wanting in both wings, while in still other species no trace of it is ever found. The portion of subcosta always preserved is the long, straight stem representing Sc_2, so that if we may judge from the form of the vein preserved and the decadent condition of the trachea of Sc_1, as shown here, the tip of the subcosta as preserved throughout the higher Lepidoptera must be Sc_2.

Humeral Cross-Vein.—The humeral cross-vein is usually preserved in the Hepialidæ. It is distinct in this species and located in its usual place between costa and subcosta near the base of the wing.

Radius.—The radius, both so far as the tracheæ and the developing veins are concerned, consists of five branches. A basal stem dividing dichotomously into an unbranched vein, R_1, and a stem which divides dichotomously into R_{2+3} and R_{4+5}. Each of these in turn divide dichotomously, the anterior into R_2 and R_3 and the posterior into R_4 and R_5. The number of branches and their method of dividing is identical with the hypothetical type. The radius of the hind wings of *Hepialus* as is common in the Jugatæ, contains as many branches as the radius of the front wings.

Media.—The media of both wings is similar in form and consists of three branches. The median trachea of each wing lies in the same vein cavity as the radial trachea at the proximal end of the wing. They extend along side by side for some distance, then the medial trachea bends away from the radial trachea, and pass into the median vein cavity. The median tracheæ branch dichotomously near the base of each wing, the anterior branch from this dichotomy after a short distance divides again dichotomously into M_1 and M_2. The posterior branch from the first dichotomy passes unbranched directly to the wing margin. This branch of media in the hypothetical type gives rise to M_3 and M_4. None of the pupal wings of *Hepialus* examined gave indication of smaller

branches arising from this trachea. The cross-veins are all without tracheæ as is the usual condition in generalized wings. The posterior branch arising at the first dichotomy of media in *Hepialus* is undoubtedly the homologue of the posterior branch at the first dichotomy of media of the hypothetical type. This branch in the hypothetical type divides dichotomously

Fig. 1. Hepialus thule, pupal wings.

into M_3 and M_4, so that this branch in *Hepialus* must represent M_3 and M_4 or as it is here labelled, M_{3+4}. The position of the branch M_4 in the Lepidoptera has not been definitely placed. Comstock and Needham figure the wings of *Sthenopis*, in the hind wing of which there is an extra branch on Cu_1, which they label as M_4. This would mean, if this interpretation is correct, that M_4 is coalesced with Cu_1 in the higher Lepidoptera. The wings figured are of a species in which Cu_1 is usually unbranched. The specimen figured is undoubtedly an abnormal specimen so far as the branching of Cu_1 is concerned and should have no weight in deciding what has become of M_4. That the above authors were in doubt is shown by the following foot-note taken from their paper: "With our present knowledge it is impossible to determine the way that vein M_4 has disappeared in the Frenatæ. We have seen no indication that it coalesces with vein Cu_1 as in *Sthenopis*, for in all pupæ of this suborder that we have examined the medial trachea is only three-branched. We are obliged, therefore, to omit any further reference to this vein in the discussion of this order." The venation of certain species of *Hepialus* is frequently abnormal. This is strikingly true of *Hepialus humuli*. I have seen wings which had extra branches on both media and radius. In the case of radius, specimens have been examined that contained six, seven, and even eight branches. So that the condition figured in the hind wing of *Sthenopis* is not unusual. The fact that none of the pupal wings showed any branching of this portion of the tracheæ of media in either wing and the further fact that *Hepialus* is one of the most generalized of lepidopterous insects, where of all places positive evidence should be sought for demonstrating this point, the interpretation must be, that the third branch of media in both wings, not only of *Hepialus* but of the Lepidoptera, is M_{3+4}.

Radio-Medial Cross-Vein.—The radio-medial cross-vein is distinct, in its usual place between R_5 and M_1, and is not preceded by a trachea.

Medial Cross-Vein.—The medial cross-vein is present, distinct, in its usual position between M_2 and M_3, and is not preceded by a trachea.

Cubitus.—The vein cavity of the cubitus of the front wings is located some distance behind the radio-medial vein cavity. It is free for a short distance at the base of the wing, then is

fused with another vein to a point opposite the point of separation of media and radius. Here the cubitus bends abruptly toward the apex of the wing for a short distance and then turns abruptly again toward the wing margin, parallel with M_4. Just before reaching the wing margin, it divides into Cu_1 and Cu_2. The basal part of the cubital trachea of all the front wings studied did not lie in the cubital vein but took a short cut toward the base of the wing. With the limited material at hand it is impossible to determine whether this is a normal condition or an artifact due to the mounting. The cubital vein cavity and trachea of the hind wing is situated much nearer to the medial trachea and vein cavity than in the front wing. The cubitus extends parallel to the media until near the wing margin where it divides into two branches, Cu_1 and Cu_2.

Medio-Cubital Cross-Vein.—The medio-cubital cross-vein is present, distinct, and in its usual position between M_3+_4 and Cu_1. This cross-vein differs from the other cross-veins in its oblique direction, a direction very suggestive that this was the course of the fourth branch of media. The entire lack of tracheæ in these veins defeats such an interpretation.

Arculus.—The arculus is a cross-vein-like structure at the base of the wing extending between radius and cubitus. The term arculus was first used for this structure in the wings of the Odonata, but as pointed out by Comstock and Needham, it is present in the wings of many insects. It is well developed in the wings of many Diptera but has not been pointed out hitherto in the wings of the Lepidoptera. The arculus, while cross-vein-like, is in reality a compound structure. The stem of media passes to the base of the wing midway between radius and cubitus to the arculus, makes an abrupt bend to the front of the wing, forming the anterior portion of the arculus, extends to radius, and then makes another abrupt bend and extends to the base of the wing in combination with radius. The posterior part of the arculus is a true cross-vein, extending from the first abrupt bend of media to the cubitus. The anterior or median portion of the arculus may be designated as the anterior arculus (*aa*) and the posterior part, consisting of a cross-vein as the posterior arculus (*pa*).

Both front and hind wings of *Hepialus thule* show a well developed arculus. Practically all of the carefully prepared drawings of the wings of the Jugatæ give some hints as to the

actual condition, though most of them indicate the media as coalesced at base with cubitus. An examination of the figures of the pupal wings of *Hepialus thule* shows the tracheæ of media lying along side the tracheæ of radius in the wing cavities of radius. A short distance from the base of the wing the median trachea diverges from the radial trachea into a broad vein cavity of its own, which passes obliquely across the wing for a short distance and then turns toward the margin of the wing between and parallel to the radial and cubital vein cavities and tracheæ. The oblique part of the median vein cavity is the anterior arculus (*aa*). Near the point where the median trachea bifurcates, a broad vein cavity joins the median vein cavity and passes obliquely, posteriorly to the cubitus. This latter oblique vein cavity is not supplied with a trachea. It is the cross-vein part of the arculus, the posterior arculus (*pa*). The posterior arculus of the front wing is much longer than that of the hind wing. This explains why in adult wings, the media frequently appears to be joined to the radius in the front wing and to the cubitus in the hind wing.

There is a great variation in the constituent parts of the arculus in the wings of different insects. This is especially true in the Diptera. A generalized condition is found in many wings, such as those of *Tabanus* or *Leptis* where the median vein joins the middle of the arculus. In such cases, the anterior arculus and the posterior arculus are subequal in length. Two lines of modification may be developed from this generalized condition. The media may migrate along the arculus nearer and nearer to the radius until it actually joins the radius. The anterior arculus through this migration becomes shorter and shorter, with a corresponding lengthening of the posterior arculus. When the media joins the radius, the anterior arculus is obliterated and the arculus is wholly cross-vein in structure or posterior arculus. If the posterior arculus atrophies in the descendants of such forms, the radius would appear to arise directly fron the radius without an abrupt bend. The second condition is found where the media migrates toward cubitus. There results a similar shortening of the posterior arculus and an elongation of the anterior arculus. This may proceed until the media is free from the arculus and coalesced with the cubitus as in the wings of *Pantarbes* or *Erax*. Whereas the cross-vein like structure was all cross-vein or posterior arculus in the first

case, in the second case it is all median or anterior arculus. A similar atrophy of the anterior arculus may take place and a condition like that found in the wings of the muscids exist, where media appears to arise from cubitus. This shows how even in the two wings of the same species, as certain Jugatæ, the media may appear to arise from the radius in the front wings and from the cubitus in the hind wings.

Anal Veins.—The front wings of *Hepialus thule* has two anal veins, each represented by a trachea. The first anal vein is coalesced for a part of its course with the stem of cubitus. many figures of wings of *Hepialus* show a cross-vein between cubitus and the first anal vein, the cross-vein is the true course of cubitus. The apparent continuation of cubitus proximad of this cross-vein is the posterior arculus. The second anal vein lies close to the wing margin and the vein cavity is not well developed. The hind wing has three well developed anal tracheæ in three equidistant vein cavities. The vein cavity of the first anal vein is not so distinct as the others.

ANATOMY OF THE TOMATO-WORM LARVA, PROTOPARCE CAROLINA.*

By Alvah Peterson.

The larvæ of *Protoparce carolina* are excellent subjects for the study of the anatomy of a developing insect. Its size and abundance during the late summer and early fall make it an available subject throughout the middle west. There are no detailed investigations of the larva of this family, so that a discussion, such as is given in the following pages, would not seem out of place. This investigation was started under Dr. A. D. MacGillivray, in order to acquire some information as to the internal anatomy of insects. Since there is such a dearth of literature dealing with the larvæ of American Lepidoptera, I have prepared, at his suggestion, the following descriptions and figures. I am greatly indebted to Dr. MacGillivary for suggestions and other help. I have found Mr. A. G. Hammer's excellent paper on the nervous system of the larva of *Corydalis cornuta* L. very useful and wish to express my appreciation of it.

METHODS.

When the work was first taken up, it was doubtful if it could be completed in one season, for only a limited amount of good material was available. There still remain a few points that need further observation, and these will be mentioned later. The best material for dissection proved to be larvæ that had been killed in hot water and preserved in 70% alcohol. Even with the largest and the best prepared specimens, one finds that the internal structures are not as easy to follow as one might expect. Especially is this true with respect to the nervous and circulatory systems. The factor causing the greatest difficulty outside of the frailty of the material, is the existence of a superabundance of adipose tissue or fat. To remove this fat, without tearing or destroying other parts, in order to observe the various organs, is difficult. The larvæ were opened by cutting a longitudinal slit along the meson on the dorsal or ventral aspects and laid out flat and pinned in dissecting trays. By gently rubbing and teasing the masses of adipose tissue, one can remove a sufficient amount to be able to observe the covered

*Contribution from the Entomological Laboratories of the University of Illinois, No. 31.

parts. Staining the tissues with a weak solution of Delafield's hematoxylin was found very useful in differentiating the finer structures. This was especially true in working with the nervous and circulatory systems. The resulting light-bluish coat given to the tissues, when not stained too deeply, proved to give the best results. Stained material will retain the stain for three or four days without becoming muddy and indistinct. To stain a certain area, the obstructing material was cleaned away and rinsed clean with running water. Pouring off all the water, two or three drops of the stain were dropped on the moist parts. The stain in no case was allowed to remain on the tissues over thirty seconds. As a general rule, the surplus stain was immediately washed off with running water.

The various parts of the larva will be discussed in the following order:—

A. External Anatomy:—Head, Thorax, and Abdomen.

B. Internal Anatomy:—Adipose Tissue, Digestive System, Silk Glands, Salivary Glands, Respiratory System, Muscular System, Circulatory System, Reproductive Organs, Wing Buds, and Nervous System.

A. External Anatomy.

The larva of *Protoparce carolina* when mature is approximately 9 cm. in length and 12–15 mm. in diameter. It has a distinct greenish cast with diagonal lines of dark brown, pigmental blotches, which extend from the dorso-caudal part of each abdominal segment ventro-cephalad. The body is divided into three regions, head, thorax, and abdomen.

HEAD (Figs. 1, 2 and 3).—The head is the smallest division of the body. It is a non-wrinkled, yellowish-white region, which from a lateral or ventral aspect is oval in outline, while from a cephalic view, it is spherical. On the median portion of the cephalic aspect, there exists a distinct inverted Y-shaped suture (*e*), the epicranial suture, which divides the fixed parts of the head into three regions. Connected with the ventral part of the region included within the arms of the Y, are the mouth parts. The large areas laterad of the epicranial suture have on their ventral aspects the antennæ and simple-eyes.

Eyes.—The simple eyes (*o*) consist of two groups of six ocelli, five of which are arranged in a semicircle with the sixth on the median part of the diameter of the circle. These groups

viewed from the cephalic aspect, are on the ventro-lateral regions of the head.

Antennæ.—Mesad and slightly ventrad of the ocelli are located the three-segmented antennæ (*at*). Each consists of a conical-shaped basal segment bearing on its distal end two similar, cylindrical segments. On the distal end of the third segment, two unequal setæ are borne, the mesal one being the longer.

Front.—The triangular area included within the arms of the Y, is the front (*f*).

Clypeus.—The clypeus (*cl*) is attached to the ventral edge of the front and forms a transverse bar, bearing a single seta on each lateral end.

Labrum.—At the apex of the clypeus, there is borne a bilobed area (*lr*), which has on its ventral edge a deep notch, which makes the labrum bilobed. On the lateral and ventral parts of these lobes are borne setæ. Three large setæ for each lobe seems to be the constant number in the various specimens examined, while there is a variation in the number of small setæ on the depressed region above the notch.

Mandibles.—The two stout mandibles (*md*) meet in a zigzag line caudad of the labrum. The zigzag line is due to the interlocking of the four dark, tooth-like projections which occur on the mesal edge of the laterally opening mandibles. The mandibles are connected to the head proper at the lateral margins of the labrum and maxillæ. Each mandible bears on its distal median portion a single seta.

Maxillæ.—Directly caudad of the proximal portion of the mandibles are two globular maxillæ (*mx*), each of which bears ventrally a three-segmented, tapering palpus. The distal segment of the palpus is very small.

Labium.—Mesad of the two maxillæ, there is a wedge-shaped labium (*lb*), which gives rise to a tubular projection at its caudo-distal edge.

Spinneret.—This tubular projection (*i*), which extends caudad and ventrad, is the spinneret, from which the silk is exuded.

THORAX.—The thorax, being the second region of the body, is adjacent to the head and consists of three segments as follows:

Prothorax (Fig. 1).—The prothorax is the cephalic segment of the thorax and is comparatively smooth and not transversely

wrinkled on its dorsal aspect. It bears on its ventral side a pair of true legs. On the caudal part of the lateral surface of the prothorax can be seen an oval spiracle.

Mesothorax and Metathorax (Fig. 1).—The mesothorax and metathorax are very similar, consequently the description of either will answer for both. Six, transverse furrows cut the dorsal surface of each segment and a pair of true legs is found on the ventral aspect of each. These two segments bear no spiracles.

Legs (Figs. 1*lg* and 5).—The three pairs of legs on the thorax are approximately alike. On all these legs numerous small setæ are borne. A leg consists of the following parts. At the base of each leg is a widened, oval, furrowed area, which constitutes the coxa (*co*) of the leg. The trochanter (*tr*), a wedge-shaped, darkened sclerite, exists on the ventro-mesal margin of the coxa adjacent to the following segment of the leg, the femur. The femur (*fe*) is the large, cylindrical segment distad of the trochanter. The tibia (*ti*) follows the femur and bends slightly mesad. The distal segment of the leg is a small, cone-shaped tarsus (*ta*), which bears on its distal end, minus an intervening suture, a single, dark-hooked claw (*ca*).

Abdomen (Fig. 1).—The abdomen is by far the largest portion of the larva, for it consists of eight, possibly nine, large segments. Some writers consider the eighth segment, as it is here called, as made up of two segments. The proleg (*a. pl*) of the last segment in this case would be attached to the ninth, while the anal horn (*ah*) would be borne on the caudo-dorsal part of the eighth segment. In the abdominal segments one to seven, a distinct similarity exists. However the abdominal segments three, four, five and six, give rise to pairs of prolegs (*pl*).

Fourth Abdominal Segment (Fig. 1).—Taking the fourth abdominal segment as a typical segment, one finds it is composed of eight, distinct, transverse, ridges on its dorsal and dorso-lateral aspects. Numerous pigmental areas can be found in the furrows. The most striking pigmental arrangement is the diagonal line of spots running from the dorso-caudal angle of the segment toward the ventro-cephalic portion. The large, oval spiracles (*s*) are located on the lateral aspects of the segments in the ventral and cephalic portion. These oval, darkened areas (Fig. 6, *s*) on magnification appear to be made up of a fine network of dark chitin and also show an indefinite,

median, dorso-ventral slit, which opens into the trachea. The prolegs (*pl*) on the ventral aspect of this segment, are a pair of fleshy appendages, which bear on their distal margins a convex, double row of black hooks, which point mesad (Fig. 4).

Eighth Abdominal Segment (Fig. 1).—The last segment of the abdomen is somewhat elongated and not so excessively cut by transverse furrows as the preceding segments of the abdomen. At the middle of the dorsal surface of the segment, a spine-like anal horn (*ah*) arises. From this point the segment is cut off obliquely at an angle of 45°. At the dorsal edge of this sloping portion the triangular anal plate (*ap*) is located. The anus (*a*) is situated ventrad of the anal plate. The anal prolegs (*a. pl*) resemble in most details the prolegs of the fourth abdominal segment. However their size is a trifle larger and the relation of their connection with the ventral surface of the segment is somewhat different. The spiracle (*s*) of this segment may be seen in its usual position.

B. Internal Anatomy.

ADIPOSE TISSUE.

On opening a larva, the first thing noted is the abundance of fat, or adipose tissue (Fig. 10). Adipose tissue, as seen throughout the body, is the white, flocculent, lobulated, ribbon-like material surrounding and adjacent to the various organs in the body cavity. This fat tissue is stored up for future metamorphosis. Sections and mounts of adipose tissue stained with eosin show (Fig. 10) its oily nature. The large spherical, fat cells in their crowded, massed condition assume a polygonal form. Internally, the cells are filled with oily globules of fat and possess also a dark-staining, centrally located nucleus. To rid the larva of this fat, one needs carefully to rub and tease it loose.

ALIMENTARY CANAL.

Extending from the mouth to the anal opening of the larva, there is a long, straight, locally constricted tube, which in the abdominal region occupies the greater portion of the body cavity. This is the alimentary canal, or digestive tract. On opening a larva from the dorsal aspect (Fig. 7), the following structures may be observed:—

Pharynx (Figs. 7, 8, and 18).—The pharynx (*p*) is the smallest part of the digestive tract and is located at the extreme

cephalic end within the head. It proceeds from the ventrally-located, mouth opening, dorsad and caudad till it enlarges into a region called the œsophagus. The more or less distinct flexure in the pharynx occurs for the most part caudad of the two head ganglia. The abruptness of this flexure depends in great part upon the position of the head. The pharynx as represented in the figures has been straightened. Arising from the pharynx are bundles of muscles that attach themselves to the head capsule.

Œsophagus.—As the pharynx begins to widen caudad of the flexure within the head, the œsophagus (*oe*) here begins and extends caudad to the ventriculus (*ve*), which is in the cephalic region of the metathorax. This trumpet-shaped piece has a finely, transversely striated ectal surface.

Ventriculus.—The ventriculus (*ve*), is a long, straight, large, transversely folded tube, which extends from the caudal end of the œsophagus to the caudal portion of the sixth abdominal segment. The transverse, folded, outer covering of the ventriculus is divided into six areas by means of six fine, longitudinal bands of muscles, which extend the full length of the ventriculus. The six bands have the following positions. One band is dorsal along the meson, one ventral along the meson, two dorso-lateral, and two ventro-lateral.

Gastric Cæca.—Located at the dorso-cephalic end of the ventriculus, between the terminations of the muscle bands, there are four groups of small, white, rounded bodies (*ce*), the gastric cæca.

Small Intestine.—Caudad of the smooth, slightly converging, caudal end of the ventriculus, there is a distinct constriction, which is immediately followed by a small ring-shaped area, the small intestine (*s. i.*) On the ectal surface of the small intestine, pits exist through which tracheæ and muscles fibres-enter. From the ventral aspect, two small bladders may be seen, which enter the small intestine at its latero-cephalic portions.

Large Intestine.—The smallest constriction in the caudal region of the alimentary tract, which is just caudad of the small intestine, is the beginning of the large intestine (*l. i.*). Immediately following this middle constriction there is a flaring shoulder, which again becomes constricted caudad, but not to as great an extent as the constriction just described. Two more small, shoulder-like areas follow this constriction, the

anterior one being very slight. This constitutes the large intestine. The above shape and form holds true only when the intestine is completely empty and relaxed. Excreta within will cause the large intestine and rectum, which follows, to assume various shapes.

Suspensory Muscle of the Large Intestine.—These two muscles (*s. m.*) extend from the ventral side of the cephalic margin of the caudal enlargement of the large intestine to the latero-ventral portion of the transverse conjuctiva, between the sixth and seventh abdominal segments. These two cord-like muscles can be best seen from the ventral aspect.

Rectum.—The rectum (*re*) is the caudal termination of the alimentary canal and occupies the caudal portion of the seventh abdominal segment and the entire portion of the eighth. The rectum is the largest in diameter of all the portions of the alimentary canal. On the dorsal surface of the rectum, there are located two prominent, longitudinal bands of muscles that converge at the cephalic end of the rectum and connect at their caudal end to the body wall. By means of the contraction of the rectum, the characteristic form is given to the excreta of lepidopterous larva.

Tracheæ of the Alimentary Canal. (Fig. 7, *t*).—The tracheæ of the oesophagus and pharynx are very small and their arrangement is difficult to trace. From the adjacent first six abdominal spiracles there is a fan-like arrangement of tracheal branches which enter the lateral, folded area of the ventriculus. These tracheæ support the ventriculus and supply it profusely with air. Tracheæ from the seventh abdominal segment lead to the large and small intestine and the cephalic area of the rectum. However, the rectum obtains most of its oxygen by means of the tracheæ coming from the eighth abdominal segment.

URINARY SYSTEM.

The urinary system (Figs. 7 and 9) of *Protoparce carolina* is composed of two bladders, right and left, and their respective tubules. Fig. 9 shows a bladder (*b*) and how it enters the anterior part of the small intestine on the ventro-lateral portion. It has been pulled out of its normal position in order to show the place of attachment of the bladder with the small intestine. It turns back on itself, as in Fig. 7, and thus conceals its place of entrance. Leading cephalad from the small, delicate, white

bladder, there is a common duct, which splits immediately and gives rise to two branches; one continues cephalad on the ventral side (*v. m. t.*), while the other passes dorsad and divides into two branches (*d. m. t.*), both of which proceed cephalad along the dorso-lateral part of the ventriculus. Tracing a ventral Malphigian tubule, we find that it extends cephalad in a nearly straight line, adjacent to the ventro-lateral portion of the ventriculus to the second abdominal segment. At this point it turns abruptly back and continues caudad and parallel with itself until it reaches approximately the seventh abdominal segment, where it becomes very convoluted and soon loses itself in the mass of convoluted, terminal, Malphigian tubules and adipose tissue. The pairs of dorsal tubules proceed cephalad and parallel into the second and third abdominal segments. The mesal tubule of the pair within the third abdominal segment, turns mesad and caudad, while the lateral tubule turns laterad and caudad within the second abdominal segment. After turning, both tubules proceed caudad and parallel with their cephalad-extending portion until they reach the sixth abdominal segment, where they turn laterad and continue into the seventh abdominal segment soon to become highly convoluted and intertwined with the ventral, terminal tubules and adipose tissue. The tubules are easily detected not only from their position, but from their form. They appear like long, white, knotted strings. The proximal portion of a tubule is more or less flattened and consists of scattered, white, globular nodules. As a tubule proceeds distad, the nodules become more frequent until finally at the terminal part of a tubule, as it enters the seventh abdominal segment, the tubule consists of a series of closely packed, irregularly arranged nodules. It was impossible to determine the termination of a tubule on account of the intertwining of the tubules, their delicate consistence, and the ever present adipose tissue.

SILK GLANDS.

Running along each side of the lateral portions of the ventriculus (Fig. 7, *sg*) and imbedded in the adipose tissue of the lateral body wall, are two opaque, smooth, yellowish-white cords. These two cords are the silk glands. They extend from the base of the spinneret on the labium into the seventh abdominal segment. The right and left silk glands of this larva

are practically of the same size thoughout their length. However, the cephalic end from the metathoracic region to the point of attachment to the spinneret is much smaller and serves probably only as a conducting tube. These conducting tubes can be traced into the head until they reach the chitinous projections on the caudal margin of the head, around which they bend at right angles and unite on the meson. Farther than this the duct was not traced. As one traces, caudad from the metathoracic region, a silk gland proper, one sees the beginning of the coiled or rather convoluted portion of this organ. Within the fifth and sixth abdominal segments the convolutions are most abundant. The gland terminates in the mass of Malphigian tubules and adipose tissue within the seventh abdominal segment.

SALIVARY GLANDS.

The two salivary glands (Fig. 7, *sl*) appear as delicate, white, nodulated, twisted tubes on each side of the pharynx and œsophagus. They extend from the anterior portion of the head to the region of the metathorax and here end within a flattened mass of adipose tissue on the ventral wall of the thorax marking the line of division between the mesothorax and the metathorax. Tracing a gland into the head, it follows along the space between the muscles and the lateral margin of the pharynx to the margin of the tendon of the adductor muscle of the mandible, where it becomes much reduced in size.

RESPIRATORY SYSTEM.

In the discussion of external anatomy, it was noted that there were nine spiracles, eight of which were abdominal and one thoracic. Opening a larva from the ventral side and removing the alimentary canal and a part of the adipose tissue, a system of more or less transparent, white, smooth tubes, similar to Fig. 11, reveals itself. To follow the tracheæ with most satisfactory results, one should open a freshly killed larva and immerse the same in water. In this case the tubes would be filled with air and appear as glistening, silver cords.

Arising from each spiracle, there is an immense, bush-like mass of tracheæ, that branch into many fine tubes, which in most cases extend to the various parts, such as muscles, nerves, alimentary canal, legs, heart, etc., of the same body segment. This holds true of the abdominal segments only. All the

spiracles of each side open into the main, longitudinal trachea which extends between the spiracles and is amply long to allow for expansion of the body segments. A unique fact, to note in regard to these connecting tracheæ, is that each gives rise to small lateral branches varying from two to six or more in number.

In examining specimens for transverse tracheal connections between spiracles of the same segment, none were found on the dorsal aspect except from the thoracic spiracle and the eighth abdominal spiracle. If other dorsal cross tracheæ exist, they must be very minute and delicate, for they were carefully sought. In the case of the eighth abdominal segment, only one minute dorsal cross trachea was found (Fig. 11), while in the prothoracic region, two distinct, cross tracheæ were observed, the cephalic one being the larger and giving rise to two pairs of tracheæ, which proceed cephalad and ventrad into the anterior portion of the head. The caudal cross trachea of the two gives rise to four or five minute pairs of tracheæ, which diverge in various directions. It should be mentioned, that the tracheal system varied considerably in minor details in different specimens. Looking on the ventral aspect for cross tracheæ, it was found that a small cross trachea existed near each ganglion of the nervous system (Fig. 13) except the supra-oesophageal ganglion, which is located dorsad and cephalad of the pharynx. The cross tracheæ adjacent to the metathoracic and mesothoracic ganglia seemed to originate from branches of the connecting tracheæ between the first and second spiracles of the body. In all cases, with one exception, the cross tracheæ lie ventrad of the nerve cord and in the abdominal region caudad of the ganglia. The one exception is the cross trachea that lies adjacent to the suboesophageal ganglion. In this case the trachea is dorsad of the commissure (*H. 2g.*). Each cross trachea on the ventral aspect gives rise to a pair of tracheæ that supplies the adjacent ganglion.

MUSCULAR SYSTEM.

In the gross treatment of the muscular system (Fig. 12) of this larva only the more prominent bands of muscles will be mentioned. The muscular system of the larva is segmentally arranged. The muscle fibres are confined in their extent to a single segment and furthermore the muscular arrangement is similar in each segment on the whole. This is especially true

with the abdominal segments. Consequently the description of a single segment will answer as a type of all the segments. The muscles of the thorax are more complex, due to the muscles of the legs.

Great Dorso-Recti Muscles (*g. d-r.m.*).—The broad area of white, opaque muscles lying to the right and left of the heart are the great dorso-recti muscles. Upon a superficial examination of the ends of the muscles at the conjunctiva, one might be led to think that the muscles were continuous, except for a slight depression. But as a matter of fact, they are contiguous and separated by a narrow, hyaline, cuticular line at the point of the depression. These particular muscles attach themselves to the cephalic side of the transverse conjunctiva.

Small Dorso-Recti Muscles (*s. d-r. m.*).—Laterad of the lateral margin of the great dorso-recti muscles, the small dorso-recti muscles are located. This band of muscles consists of three to five small fibres that are fastened to the caudal margin of the transverse conjunctiva. Laterad of this bundle of muscles an area exists, which is free of longitudinal muscles but contains the spiracles and their accompanying tracheæ.

Great Ventro-Recti Muscles (*g. v-r. m.*). If the larva is spread out as in Fig. 12, the large band of muscles laterad of the free area consists of the great ventro-recti muscles. This group is ventrad of the spiracles. These muscles attach themselves to the cephalic aspect of the transverse conjunctiva.

Small Ventro-Recti Muscles (*s. v-r. m.*).—These muscles are located mesad of the great ventro-recti muscles along the ventral area of the larva adjacent to the nervous system. They are attached to the caudal side of the transverse conjunctiva. All these muscles are supplied by tracheæ.

Dorso-Ventral Muscles (*d. v. m.*).—The dorso-ventral muscles are the two groups of short muscles that extend dorso-ventrad across the free area existing between the great ventro-recti muscles and the small dorso-recti muscles, one group at the cephalic end of the segment and the other at the caudal end. Two fibres, the cephalic group, cross immediately cephalad of the spiracle and mesad of the longitudinal trachea between the abdominal spiracles and mesad of the small dorso-recti muscles. The other remaining fibres disappear dorsally in the cephalic part of the segment as the two already described fibres but ventrally they cross at an angle the transverse conjunctiva

and disappear from view in the extreme caudal part of the preceding abdominal segment. Other muscles besides those thus far discussed are present in each body segment. By carefully lifting the longitudinal fibres, one finds other bands of muscles running at an angle to those named above. This is indicated in Fig. 12, (*x*), where in the caudo-dorsal angle of the free part about the spiracles in each segment one sees the ends of such diagonal bands.

CIRCULATORY SYSTEM.

Dorsad of the alimentary canal is a long slender tube (Fig. 12) embedded to some depth in a mesal cavity of adipose tissue between the right and left bands of the great dorso-recti muscles. This tube, which comprises the whole of the enclosed circulatory system, extends from the eighth abdominal segment to and within the head. The enlarged part of this tube, extending from the eighth abdominal segment into the metathoracic region, is the pulsating organ, the heart.

Heart.—The heart (*h*) is a very delicate, flattened, muscular tube closed at the caudal end and presumably opening in each segment by a system of valves. Owing to the lack of fresh and living material the valves of the heart were not studied. After injecting some colored fluid into fresh specimens, the valves should readily show themselves.

Wings of the Heart.—Within the area of the first to the fifth abdominal segments, four pairs of laterally extending fan-like rays of tendons (*w. h.*) are seen. The tendons extend from the ventro-lateral edges of the heart and converge at the point where the three anterior dorso-ventral muscles penetrate between the great dorso-recti muscles and the small dorso-recti muscles. The wings are composed of connective tissue and muscle fibres, connecting themselves to the body wall beneath the small dorso-recti muscles. The function of the wings of the heart is probably to protect the heart from the peristaltic movements of the alimentary canal. Between successive fans the heart proper is distinctly constricted. In these regions without much doubt the valves of the heart are located. The caudal part of the heart, extending from the midportion of the fifth abdominal segment to the caudal end, is supported by scattered, irregularly arranged tendons on the ventral surface, that attach themselves to the nearby body wall.

Aorta.—The cephalic extension of the heart, the aorta (*ao*), starting within the metathoracic region and passing into the head, is a much smaller and smoother muscular tube. It runs close to the dorsal surface of the œsophagus and the pharynx and finally terminates with a slight dilation after it has passed beneath the supra-œsophageal ganglion (Fig. 8 and 18). This location of the outlet allows a constant and abundant supply of fresh blood within the head region. The mouth-like opening of the aorta is held in its characteristic position by means of tendons that connect themselves to the head capsule (Fig. 8).

The heart, like the other organs of the body, is well supplied with air tubes. The arrangement of the heart-tracheæ is shown in the fifth abdominal segment (Fig. 12).

REPRODUCTIVE ORGANS.

After examining numerous specimens for gonads, two white, opaque, ovate bodies (Fig. 12, *r*) were found on each side adjacent to the heart in the fifth abdominal segment. Difficulty was experienced in locating these organs on account of their close similarity to adipose tissue and their being embedded in the same. It was impossible to determine the sex of the glands on account of the limited material at hand. From the fifth abdominal spiracle, tracheæ arise that supply the reproductive organs.

WING BUDS.

The wing buds (*f. b.* and *h. b.*) are the histoblasts, imaginal discs, or imaginal buds of the future wings of the adult insect. They are formed as invaginations of the hypodermis, to which they are attached. They are small, kidney-shaped bodies located in the dorso-lateral portions of the mesothorax and metathorax. If a larva is cut along the ventral meson, the wing buds will be seen about midway between the meson and the outer cut body wall. Two tracheæ enter the wing buds at their base, one into the caudal portion and the other into the cephalic portion.

NERVOUS SYSTEM.

The nervous system (Fig. 13) of *Protoparce carolina* consists of a long, white cord, knotted at segmental intervals, which extends for the most part along the meso-ventral portion of the body. This ventrally located, simple nervous system is made up of three parts: ganglia, commissures, and nerves. The

enlarged, oval knots, found in each segment of the body, are the ganglia. Only one ganglion exists in each body segment outside of the head and the seventh and eighth abdominal segments. The cords running between the ganglia, which in some cases are double or partially so, are the commissures. The nerves are the branches of various sizes extending from each ganglion and in some cases from the commissures. These fine threads permeate all parts of the body. The nervous system will be discussed under the following divisions: Abdominal Ganglia, Thoracic Ganglia, Head Ganglia, and Sympathetic Systems of the Head.

ABDOMINAL GANGLIA (Fig. 14 and 15).—The abdominal ganglia are the simplest in type. The distinct similarity between the first six abdominal ganglia makes it possible for one description to answer for all. The seventh and eighth abdominal ganglia will be discussed under a separate heading.

First Six Abdominal Ganglia (Fig. 15, *A*. 1*g*).—The first six abdominal ganglia are located in the middle or cephalic part of each abdominal segment and consist of the following parts:—

Lateral Nerves.—The lateral nerves (*l*) are the two branches, which arise from the cephalic part of the lateral margins of the ganglia and innervate the latero-dorsal portion of the body.

Ventral Nerves.—Directly caudad and slightly ventrad of the lateral nerves, the ventral nerves (*v*) arise and extend caudo-laterad to innervate the ventral area of the body segments Near the point of entrance of the ventral nerves, a pair of small nerve-like tracheæ enter the ganglia. These two tracheæ, one on each side, are derived from the transverse tracheæ located in each abdominal segment ventrad of the nerve cord. The tracheæ can be distinguished from the nerves by staining with Delafield's hematoxylin as heretofore advocated. A stained trachea is more deeply colored than a nerve and also shows its distinct ringed nature on high magnification.

Ventral Sympathetic System (Fig. 15, *m*. and *t. n*.).—Extending between the ganglia there is a single, large, white cord, the commissure. Just before the commissure enters the cephalic end of a ganglion, it divides into two cords or is furrowed on the dorsal surface. The ventral sympathetic nerves arise from the cephalic end of this fork. With some of the ganglia, this forking or splitting of the commissure is not very great but can in each case be detected.

Median and Transverse Nerves.—The median nerve (*m*) arises from the commissure at the cephalic end of this inverted V-shaped split and extends caudad for a short distance. At its caudal end near the ganglion, it forks and gives rise to two transverse nerves (*t. n.*), that extend in opposite lateral directions and more or less parallel with the lateral nerves. In the short distance in which the transverse and lateral nerves are parallel, the transverse nerves give rise to a web of nerve fibres (*px*), which connect with the lateral nerves and the ganglion. Beyond this web or plexus, the transverse nerves diverge from the lateral nerves in a cephalo-lateral direction.

Ganglia Seventh Abdominal Segment. (Fig. 14, *A*. 7 and 8 *g*). —Within the seventh abdominal segment, is a double ganglion, or rather two ganglia, but no visible commissure connects the two because of the close approximation of the ganglia. This modification brings about a change in the nerves.

Seventh Abdominal Ganglion.—The seventh abdominal ganglion is comparable to the ganglia of the first six abdominal segments. It gives rise to nerves arranged in the same manner and does not need further description.

Eighth Abdominal Ganglion.—The elimination of the commissure between the seventh and eighth ganglia has not only brought the ganglia together but has lengthened as well as changed the place of origin of the nerves from the ganglion.

Lateral Nerves.—The comparatively large lateral nerves (*l*) arise not from the lateral margin of the ganglion but from its dorso-caudal end and extend with a slight divergence far into the eighth abdominal segment before branching.

Ventral Nerves.—Ventrad and slightly laterad of the lateral nerves, there arises a small pair of ventral nerves (*v*), which also extend into the eighth abdominal segment before branching. Adjacent to these ventral nerves the accompanying tracheæ, which resemble nerves closely enter the ganglion. The ventral trachea of the eighth abdominal segment, however, still exists in its normal position within the eighth segment. This elongates to a great extent the pair of tracheæ that arise from it to supply the eighth abdominal ganglion.

Ventral Sympathetic System (Fig. 14, *m*. and *t. n.*).—The fusing of the seventh and eighth abdominal ganglia causes the sympathetic system apparently to arise from the dorso-caudal end of the seventh abdominal ganglion.

Median and Transverse Nerves.—The median nerve (*m*) arises from the mid-dorsal area of the double ganglion. It is very short. On teasing apart the two ganglia, the median nerve remains attached to the caudal end of the seventh abdominal segment. It immediately gives rise to its pair of transverse nerves (*t. n.*), which extend caudo-laterad into the eighth abdominal segment more or less parallel to and laterad of the pair of lateral nerves. However, no plexus exists between the transverse and lateral nerves of this ganglion, as was noted in the other segments.

THORACIC GANGLIA (Fig. 17, *T.* 1*g*, and *T.* 2*g*, Fig. 16, *T.* 3*g*).—The thoracic ganglia are three in number, the mesothoracic and metathoracic ganglia are similar in form.

Mesothoracic and Metathoracic Ganglia (*T.* 2*g* and *T.* 3*g*).—The mesothoracic and metathoracic ganglia are slightly larger than the abdominal ganglia and are not as far apart. Extending from the caudal ends of all the thoracic ganglia, there is a large commissure (Fig. 17) which, in case of the prothoracic and mesothoracic, proceeds but a short distance and then forks and forms the diamond-shaped area in which the ventral sympathetic nerves are located. In both cases, the diamond-shaped area between the metathoracic and mesothoracic and between the mesothoracic and prothoracic ganglia occupies about two-thirds of the distance between the ganglia.

Lateral Nerves.—The lateral nerves (*l*) proceed from the ganglia at their latero-cephalic part and are adjacent to the lateral edges of the commissures. The lateral nerves extend in a latero-cephalic direction.

Connective Nerves.—The connective nerves (*c. n.*) arise from the lateral edges of the commissure and extend in a caudal direction. In the case of the diamond-shaped area between the mesothoracic and metathoracic ganglia, the connective nerves arise midway between the anterior and posterior angles of the diamond. While, with the diamond-shaped area between the prothoracic and mesothoracic ganglia, the commissure gives rise to its connective nerves very much nearer the mesothoracic ganglion than to the anterior end of the opening. The connective nerves proceed a short distance caudad, then turn laterad and somewhat cephalad, and soon fuse with the lateral nerves laterad of their connection with the commissure. Before fusing with the lateral nerves, the connective nerves give rise

to a branch that extends cephalad and somewhat parallel with the lateral nerves. This branch soon forks, one branch extends laterad across the lateral nerve, the other branch cephalo-laterad and parallel with the lateral nerve.

Ventral Nerves.—In the mesothoracic and metathoracic ganglia, the ventral nerves (*v*) arise from the lateral margin of each ganglion in a plane ventrad of the lateral nerves. The metathoracic, ventral nerves extend cephalo-laterad, while the ventral nerves of the mesothoracic ganglion project directly laterad. In both cases the ventral nerves innervate the ventral portion of the body. At the point of entrance of the ventral nerves, one finds the usual tracheæ that supply the ganglion with air.

Ventral Sympathetic System (Fig. 16, *T.* 3*g*, Fig. 17, *T.* 2*g*.)—With the mesothoracic and metathoracic ganglia, the ventral sympathetic system consists of a median nerve and transverse nerves.

Median and Transverse Nerves.—The median nerves (*m*) arise from the commissure in the cephalic angle of the diamond-shaped areas and in both cases are of considerable length before the fork. The mesothoracic median nerve is longer than the metathoracic median nerve. In both cases the transverse nerves (*t. n.*), after arising from the caudal end of the median nerve, proceed in such a direction as to cross the commissure at the point near where the connective nerves arise. After crossing the commissure, they tend to take, as usual a course parallel to the lateral nerves. The web or plexus (*px*) of nerves in these two ganglia is very distinct; this is especially true in the metathoracic ganglion. The plexus occurs principally in the triangular area between the commissures, the lateral nerves, the transverse, and the connective nerves. In Fig. 17 (*T.* 1*g*, *T.* 2*g*), one may note a dark line drawn from the median portion of the prothoracic ganglion caudad. The true connection and relation of this nerve-like thread was not determined.

Prothoracic Ganglion (Fig. 17, *T.* 1*g*).—The prothoracic ganglion is very similar in form and in the arrangement of its nerves to the abdominal ganglia. As heretofore mentioned, the commissure, which projects caudad from the prothoracic ganglion, is simple and large. The ganglion cephalad of the prothoracic ganglion is the subœsophageal ganglion and is located only a very short distance from the prothoracic ganglion.

The commissure extending between these two ganglia fail to unite before entering the caudal end of the subœsophageal ganglia; consequently the two ganglia are connected by two distinct parallel strands.

Lateral Nerves.—The lateral nerves (*l*) are the two branches which arise from the cephalic part of the lateral margins of the ganglion. These nerves soon divide into many small branches and innervate the lateral areas of the prothorax.

Ventral Nerves.—The ventral nerves (*v*) project from the caudo-lateral margin and are accompanied by the usual pair of tracheæ. In this ganglion however, the ventral nerve of each side is not single but is composed of two small branches.

Ventral Sympathetic System.—With the prothoracic ganglion, the customary median and transverse nerves are wanting but the following new arrangement exists:—

Subconnective Nerve (Fig. 17, *T.* 1g).—Dorsad and cephalad of the prothoracic ganglion, the large subconnective nerves (*sn*) exist, which cross the commissure. Within the region adjacent to the ganglion, a plexus or web of nerves (*px*) extends between the subconnective nerve, the ganglion, and the proximal ends of the lateral nerves.

GANGLIA OF THE HEAD (Fig. 17, *H.* 1g and *H.* 2g, Fig. 18).—In the alimentary tract as it extends to the mouth by means of the pharynx, there is to be noted a distinct flexure in the head. The two head-ganglia are located slightly distad of this flexure. The corresponding flexure in the nervous system is located between the subœsophageal and prothoracic ganglia. The two head-ganglia rest on the pharynx but on opposite sides (Fig. 18). The more distal ganglion, the supraœsophageal (*sp*), is cephalad of the pharynx and entad of the front of the head capsule. The subœsophageal ganglion (*su*) is caudad of the pharynx and connected to the supraœsophageal by means of two commissures, which together with the two ganglia form a complete ring about the pharynx.

Suboesophageal Ganglion (Fig. 17 and 18, *su*).—The subœsophageal ganglion is located caudad of the pharynx and in a plane ventrad of the supraœsophageal. It gives rise to the following nerves:—

Crura Cerebri.—The crura cerebri (*c. c.*) arise from the cephalo-ventral portion of the lateral margin of the subœsophageal ganglion very close to the pharynx. This pair of large

cords arising from the lateral margins help to complete the circle about the pharynx by connecting themselves to the latero-caudal portions of the supraœsophageal ganglion.

Mandibular Nerves.—Adjacent to the crura cerebri and extending in a caudo-mesal direction, there arises a pair of nerves (*md. lb. n.*), which are of approximately the same size as the crura cerebri. These nerves extend ventrad and divide into two nerves of unequal size; the larger nerve (*md. n.*) proceeds cephalad and ventrad and innervates the mandible.

Labial Nerves.—The labial nerves (*lb. n.*) arise from the mesal side of the mandibular-labial nerve (*md. lb. n.*). They extend ventro-caudad and innervate the labium.

Maxillary Nerves.—Caudad and adjacent to the mandibular nerves, the maxillary nerves (*mx. n.*) arise. They are smaller and soon branch and innervate the maxillæ.

Unidentified Nerves.—Caudad and slightly dorsad of the maxillary nerves, there arises on each side a nerve of considerble size (*z*), which extends laterad into the muscles of the head toward the salivary ducts but I have been unable to determine what they innervate.

Ventral Nerves.—From the mid-lateral area of the ganglion, the ventral nerves (*v*) project accompanied by their accustomary tracheæ. In this ganglion a light stain brings out very successfully the branches of the tracheæ (*t*) as they radiate over the surface of the ganglion. The ventral nerves in this case project dorso-caudad into the caudal part of the head.

Supraœsophageal Ganglion (Fig. 17 and 18, *sp*).—The supraœsophageal ganglion (*sp*) is the largest ganglion of the nervous system and is located on the cephalic surface of the pharynx. The transverse diameter of the ganglion is about twice that of the ventro-dorsal diameter. The ganglion is constricted along the meson into two lobes. The following nerves arise from this ganglion:—

Crura Cerebri.—The two large crura cerebri (*c. c.*) that proceed from the subœsophageal ganglion in a dorso-cephalic direction, connect with the supraœsophageal ganglion on the latero-dorsal margins. The two trunks are comparable to the commissures that extend between the ganglia in other regions of the body. Just dorsad of where the crura cerebri arise from the supraœsophageal ganglion, a large trachea enters the ganglion on each side of the head. These tracheæ, a short distance from

the ganglion, fork, one branch extending ventrad and the other more or less dorsad. These particular tracheæ arise from branches that lead into the head from the spiracle located in the prothorax.

Subœsophageal Commissures.—The subœsophageal commissures (*s. c.*) are the branches that arise from the ventral side of the crura cerebri near the supraœsophageal ganglion. These two branches encircle the pharynx. On the caudal part of this semicircle two small branches occur which extend dorsad and innervate the large muscle fibres of the pharynx. These semicircular nerves have received the name of commissures, but a comparison with other ganglia shows that they are not the true commissures. The crura cerebri should be called the commissures. It is probable that the so-called subœsophageal commissures are nothing more than connective nerves that have united to form a semicircle about the pharynx. The following nerves arise from the supraœsophageal ganglion:—

Optic Nerves.—The small optic nerves (*o. n.*) arise the most cephalad of any of the nerves from the supraœsophageal ganglion and without branching extend to the groups of ocelli on each side of the head where they break up into small branches and supply each ocellus.

Antennal Nerves.—The antennal nerves (*at. n.*) are of about the same size as the optic nerves and arise from the ganglion caudad of and adjacent to the optic nerves, and extend cephalad and ventrad. Not far from the ganglion, they fork and form two branches, one of which innervates the area at the base of the antenna and the other the antenna itself.

Clypeo-Labral Nerves.—The pair of clypeo-labral nerves (*cl. lr. n.*) are the most caudal pair of the nerves arising from this region of the supraœsophageal ganglion. Each clypeo-labral nerve gives rise to several cephalo-mesal extending nerves and one caudo-lateral branch. The latter branch, arises from the clypeo-labral nerve in a plane slightly ventrad of the frontal ganglion and terminates in an enlarged ganglion-like structure on the labral aspect of the pharynx. This ganglion-like structure gives rise to several small nerves. The first cephalo-mesal branch from the clypeo-labral nerve is very short and arises in a plane slightly dorsad of the frontal ganglion. The succeeding or second cephalo-mesal nerve from the clypeo-labral nerve connects with the Y-shaped branch given off from the frontal

ganglion. In different specimens examined variations often occurred in respect to the exact origin of these nerves. For example, it was found that in some cases this second cephalo-mesal nerve arose at times ventrad of the caudo-lateral branch, while in the majority of cases it arose from the clypeo-labral nerve dorsad of the caudo-lateral branch. Further ventrad on the clypeo-labral nerves two or three other cephalo-mesal nerves project and innervate the cephalic area of the pharynx.

SYMPATHETIC SYSTEMS OF THE HEAD (Fig. 17 and 18).—Two sympathetic systems exist in connection with the supra-œspohageal ganglion. The vagus system is an unpaired system while the sympathetic system located laterad and dorsad of the pharynx is paired.

Vagus or Unpaired Sympathetic System (Fig. 17 and 18).—The vagus system originates from the ventro-lateral part of the supraœsophageal ganglion near the clypeo-labral nerve and consists of the following parts:—

Arched Nerves.—The pair of arched nerves (*ar*) is one of the pairs of nerves which arise from the ventro-lateral area of the supraœsophageal ganglion and project ventrad on each side of the head adjacent to and somewhat cephalad of the clypeo-labral pair of nerves. They extend a short distance ventrad in a curved line then turn mesad and unite on the meson ventrad of the supraœsophageal ganglion and form a small ganglion.

Frontal Ganglion.—The enlarged, fused, mesal part of the arched nerves is the frontal ganglion (*f. g.*). It rests on the pharynx and is located caudad beneath the mouth-like opening of the aorta (Fig. 8). Nerves entrad and dorsad extending arise from this ganglion.

Frontal Nerve.—The nerve extending ventrad from the frontal ganglion is the frontal nerve (*f. n.*). It is very short and soon divides into two branches which proceed latero-ventrad for a short distance and then turn directly ventrad. At the point where they turn ventrad, the second cephalo-mesal branch arising from the clypeo-labral nerve fuses with them.

Recurrent Nerve.—The nerve extending dorsad on the meson from the frontal ganglion is the recurrent nerve (*r. n.*). It extends in its dorso-caudal course between the aorta and the pharynx and œsophagus (Figs. 8 and 18). As it continues its course between these organs, it follows the flexure of the pharynx so that it extends caudad as well as dorsad. In its course along

the cephalic and dorsal surface of the pharynx and œsophagus, it gives rise to paired and unpaired laterad extending branches which innervate the cephalic and dorsal parts of the pharynx and œsophagus respectively and probably also the aorta. As the recurrent nerve approaches the caudal end of the œsophagus, it divides into two branches, which pass around the side of the œsophagus.

Vagus Ganglion (Fig. 7, *v. g.*).—At the point of the forking of the recurrent nerve near the ventriculus, a minute ganglion exists, the vagus ganglion (*v. g.*).

Stomogastric Nerves (Fig. 7, *st.*).—The branches that proceed from the vagus ganglion on each side are the stomogastric nerves (*st*). These nerves curve laterad around the oesophagus and innervate its caudal portion.

Paired Sympathetic System (Fig. 17 and 18).—On each side of the pharynx dorsad of the supraœsophageal ganglion, a sympathetic system exists, composed of two distinct nerves and two ganglia.

Lateral Nerve.—Just dorsad and slightly mesad of the large trachea that enters the supraœspohageal ganglion is the point of origin of the very small lateral nerve (*l*). This nerve continues dorsad and slightly caudad till it ends in an enlarged, irregular, ovate-shaped ganglion on the lateral aspect of the pharynx cephalad of the subœsophageal ganglion. Running parallel with this nerve is a minute treachea which resembles a nerve very closely and is easily mistaken for one. This trachea is not indicated in Fig. 18. Often the lateral nerve, before entering the anterior, lateral ganglion, gives rise to a small branch which either connects directly with the ganglion or with the fronto-lateral nerve.

Anterior Lateral Ganglion.—The ganglion in which the lateral nerve ends, is the anterior lateral ganglion (*a. l. g.*). This ganglion gives rise on its caudal and cephalic ends to two or three nerves of various sizes which extend caudad between the muscles of the pharynx. On its dorsal margin, it gives rise to a lateral commissure (*l. c.*) which connects with the posterior lateral ganglion.

Fronto-Lateral Nerve.—The fronto-lateral nerve (*f. l.*) arises from the cephalic end of the anterior lateral ganglion adjacent to and cephalad of the point where the lateral nerve enters. The fronto-lateral nerve continues ventrad to the caudo-lateral

aspect of the supraœsophageal ganglion and connects with the ganglion by means of a short stub and then continues ventrad into the head for a considerable distance.

Lateral Commissure.—The lateral commissure (*l. c.*) is a short nerve that arises from the middle of the dorsal surface of the anterior lateral ganglion and unites with a larger ganglion dorsad and caudad of the anterior lateral ganglion. This commissure gives rise to a nerve which extends ventrad.

Posterior Lateral Ganglion.—The posterior lateral ganglion (*p. l. g*). is larger than the anterior lateral ganglion and is located dorsad and somewhat caudad of it. It likewise gives rise to several nerves at its caudal and cephalic ends.

EXPLANATION OF PLATES.

PLATE XIX.

Fig. 1. Lateral aspect of an entire larva of *Protoparce carolina.*
Fig. 2. Cephalic aspect of the head.
Fig. 3. Ventral aspect of the head.
Fig. 4. Ventral aspect of an abdominal proleg.
Fig. 5. Cephalic aspect of a thoracic leg.
Fig. 6. Spiracle, enlarged.
Fig. 7. A larva opened from the dorsal aspect showing the digestive tract. On the left the salivary glands and the tracheæ are represented which enter the canal, while on the right the malphigian tubules and silk glands are shown.
Fig. 8. Dorsal aspect of the pharynx, enlarged.
Fig. 9. Enlarged ventral aspect of the region of the alimentary canal, showing where the bladder of the malphigian tubule is attached.
Fig. 10. Cells of the adipose tissue, enlarged.

PLATE XX.

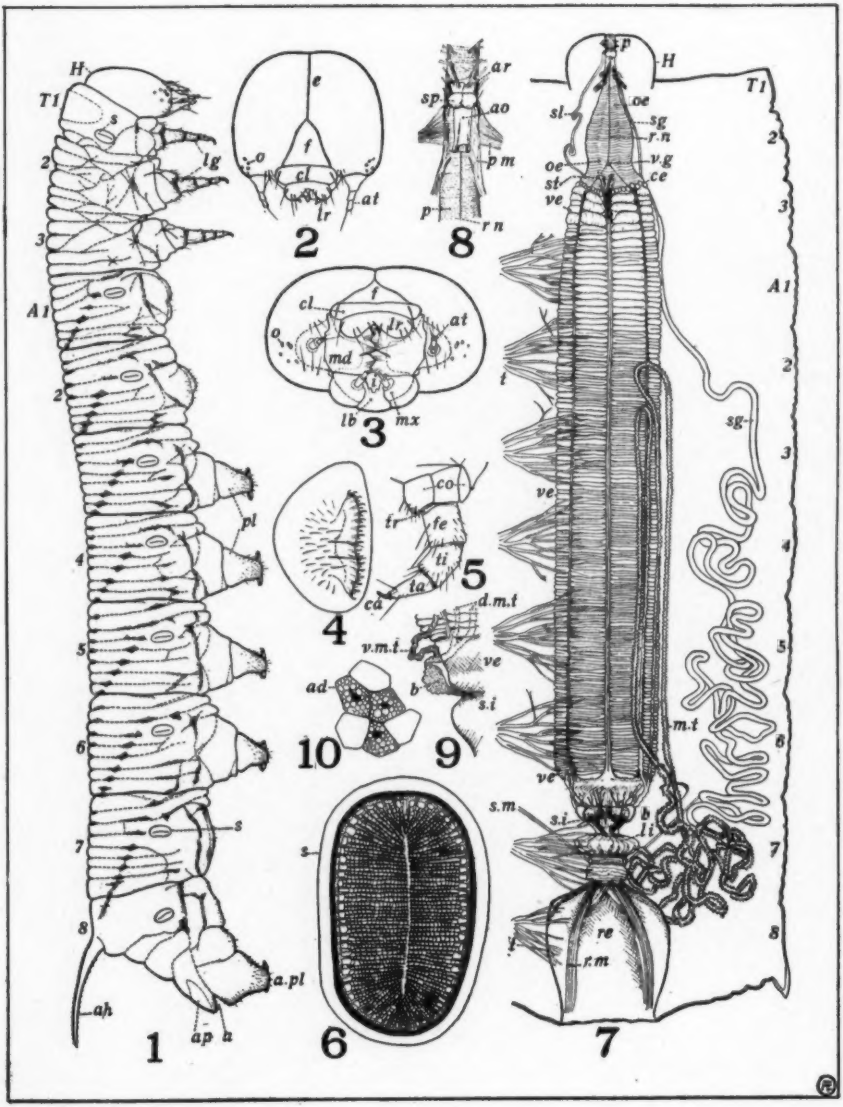
Fig. 11. A larva opened from the ventral aspect showing the respiratory system.
Fig. 12. A larva opened from the ventral aspect showing the muscular system, circulatory system, reproductive organs, and wing buds.

PLATE XXI.

Fig. 13. A larva opened from the dorsal aspect showing the entire nervous system.
Fig. 14. Dorsal aspect of the seventh and eighth abdominal ganglia.
Fig. 15. Dorsal aspect of the first abdominal ganglion.
Fig. 16. Dorsal aspect of the metathoracic ganglion.
Fig. 17. Dorsal aspect of the mesothoracic ganglion (*T. 2g*), prothoracic ganglion (*T. 1g*), subœsophageal ganglion (*H. 2g*), and the supraœsophageal ganglion (*H. 1g*).
Fig. 18. Lateral aspect of the pharynx showing the nerves of the supraœsophageal and subœsophageal ganglia.

LIST OF ABBREVIATIONS.

A.	Abdomen.
A. 1-8.	Abdominal segments one to eight.
a.	Anus.
ad.	Adipose tissue.
an.	Anal horn.
a. l. g.	Anterior lateral ganglion.
ao.	Aorta.
ap.	Anal plate.
a. pl.	Anal proleg.
ar.	Arched nerve.
at.	Antenna.
at. n.	Antennal nerve.
b.	Bladder of malphigian tubule.
c.	Commissure.
c. c.	Crura cerebri.
ca.	Claw.
ce.	Cæca.
cl.	Clypeus.
cl. lr. n.	Clypeo-labral nerve.
c. n.	Connective nerve.
co.	Coxa.
d. m. t.	Dorsal malphigian tubule.
d. v. m.	Dorso-ventral nerve.
e.	Epicranial suture.
f.	Front.
f. b.	Mesothoracic wing bud.
f. e.	Femur.
f. g.	Frontal ganglion.
f. n.	Frontal nerve.
g.	Ganglion.
g. d.-r. m.	Great dorso-recti muscles.
g. v.-r. m.	Great ventro-recti muscles.
H.	Head.
h.	Heart.
h. b.	Metathoracic wing bud.
i.	Spinneret.
l.	Lateral nerve.
lb.	Labium.
lb. n.	Labial nerve.
l. c.	Lateral commissure.
lg.	Leg.
li.	Large intestine.
lr.	Labrum.
m.	Median nerve.
md.	Mandible.
md.-lb. n.	Mandibular-labial nerve.
md. n.	Mandibular nerve.
m. t.	Malphigian tubule.
mx.	Maxilla.
mx. n.	Maxillary nerve.
o.	Ocelli.
oe.	Œsophagus.
o. n.	Optic nerve.
p.	Pharynx.
pl.	Proleg.
p. l. g.	Posterior lateral ganglion.
p. m.	Pharyngeal muscle.
px.	Plexus.
r.	Reproductive organ.
re.	Rectum.
r. n.	Recurrent nerve.
r. m.	Rectal muscle.
s.	Spiracle.
s. c.	Subœsophageal commissure.
s. d.-r. m.	Small dorso-recti muscles.
sg.	Silk gland.
s. i.	Small intestine.
sl.	Salivary gland.
s. m.	Suspensory muscle.
s. n.	Subconnective nerve.
sp.	Supraœsophageal ganglion.
st.	Stomogastric nerve.
su.	Subœsophageal ganglion.
s. v.r-. m.	Small ventro-recti muscles.
T.	Thorax.
T. 1-3.	Thorax segments, prothorax, mesothorax and metathorax
t.	Trachea.
ta.	Tarsus.
ti.	Tibia.
t. n.	Transverse nerve.
tr.	Trochanter.
v.	Ventral nerve.
ve.	Ventriculus.
v. g.	Vagus ganglion.
v. m. t.	Ventral Malphigian tubule.
wh.	Wings of the heart.
x.	Unidentified muscle.
z.	Unidentified nerve.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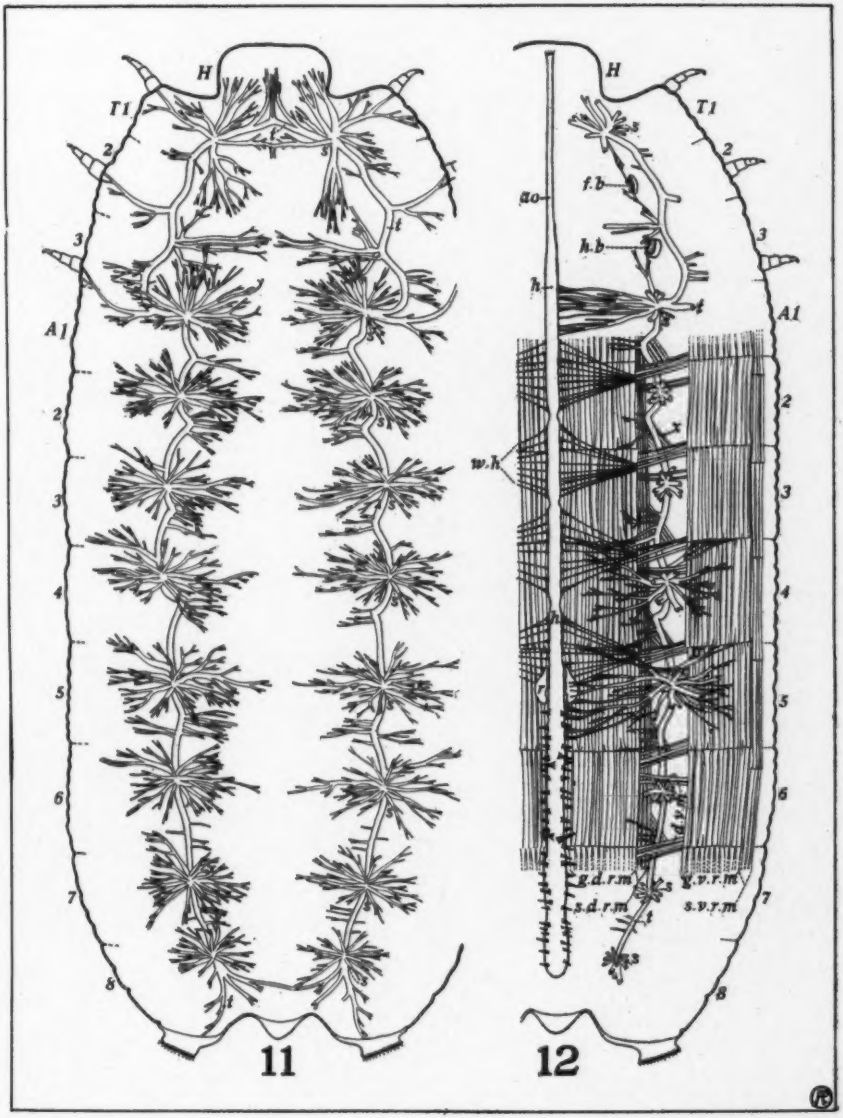
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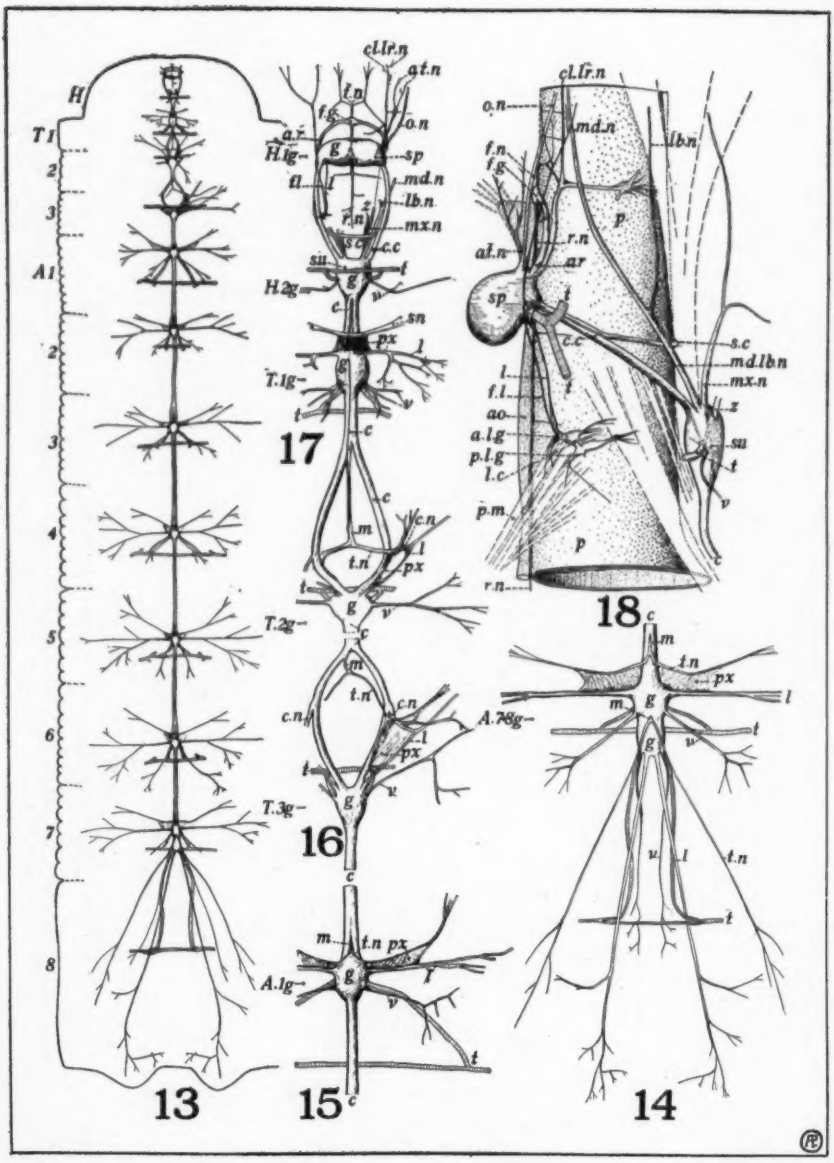
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A. Peterson.

OBSERVATIONS ON THE ECOLOGY OF DRAGON-FLY NYMPHS: REACTIONS TO LIGHT AND CONTACT.*

By C. F. Curtis Riley.

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IX. Formation of Groups.
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XVI. Summary and Conclusion.

INTRODUCTORY.

The greater part of this work was completed several years ago. Publication has been delayed through various causes; chiefly because it had been the purpose of the writer to incorporate other experiments in the paper. The present communication is really an abstract of a more detailed piece of research which is practically completed, except for certain minor matters.

The research was undertaken at the suggestion of Professor S. J. Holmes. The writer desires at this point to express his appreciation of Doctor Holmes's kindly criticisms and also of his stimulating interest in the work of those associated with him. Thanks are also due to Doctor C. C. Adams for free access to his library and for many helpful suggestions.

The work was done upon certain forms of Agrionid nymphs. Many hundreds of different individuals were used in the experiments. It proved to be impracticable to identify the forms as the work progressed. A representative series of the nymphs were sent away for determination and, unfortunately, were lost in the mail. No essential differences have been found in the reactions of the different species, other than those of differences in degree, as evidenced in a few cases by relative inertness and activity.

*Contributions from the Zoölogical Laboratory of the University of Illinois, under the Direction of Henry B. Ward, No. 20.

The insects were collected in the vicinity of Ann Arbor, Michigan, from various ponds, lakes, and marshy ground along the margins of streams. The Three Sister Lakes formed an excellent environment for collecting the nymphs. A large number of the organisms were taken in a pool, directly below the milldam, formed by the overflow of the Huron River, at Ann Arbor.

METHODS.

The experiments were performed in a dark room kept at a temperature of about 22°C. The intense artificial light was from the electric arc of a Thomson projection lantern. For the weaker artificial light, a 16 c. p. electric incandescent light was used. Experiments were also performed with diffused daylight, its source being a south window 5 m. distant from the dark room. The light entered through a small circular opening in the side of the dark room. The nymphs were placed in a glass trough with parallel sides which was half filled with tap-water. The trough was then placed on a table top, painted black. The table was so situated that the glass vessel lay in the beam of light, entering through the circular opening, with its long axis practically parallel with the rays of light.

RESPONSES IN NATURAL HABITAT.

In their natural habitat, Agrionid nymphs react strongly to contact. They are found clinging tightly to the stems, branches, and leaves of *Elodea* and *Ceratophyllum*. This is an indication of their decided thigmotactic proclivities. They tend to place as much as possible of the external parts of their bodies in contact with a solid surface. This is accomplished by clinging to the aquatic plants, in such a manner that the long axes of their bodies lie parallel to the long axes of the stems and the branches. The nymphs frequently assume a somewhat different position, with the long axes of their bodies rather oblique to the long axes of the stems and branches. The creatures are frequently found with their bodies closely applied to the *Elodea* and *Ceratophyllum* at the points where the branches are given off—that is, in the forks formed by the stem of the main plant and the lateral branches. They are also found on both plants in the angles formed by the whorls of leaves arranged around the stem. Pearl (1903, pp. 560–562) records similar observations in his work on Planarians. This writer has given the name

goniotaxis to such responses. In an interesting paper on the death-feigning of *Belostoma*, Severin and Severin (1911a, p. 38) have described how this insect also reacts to the contact of aquatic vegetation.

The dragon-fly nymphs lie in wait for their prey on these aquatic plants. They are effectually concealed in such positions. The diameter of their bodies is about that of the thicker stems, and the creatures lie so quietly that they are easily overlooked. Then also their colors are much like those of the vegetation—browns and greens predominating. Facts of somewhat similar nature have been recorded by Holmes (1905, pp. 308–309) in his observations on *Ranatra*. In collecting the dragon-fly nymphs, the writer often rakes some of the plant material out of the water. The animals are then picked from the *Elodea* and *Ceratophyllum*. It is not at all an uncommon thing for many of them to be overlooked; because after the plants have been taken to the laboratory and placed in an aquarium jar containing water, the nymphs can be seen swimming about freely or resting on the bottom. Having been disturbed in transit, they frequently leave their positions on the aquatic vegetation. The reason that some of them are so easily overlooked is due to three facts. First, they remain very quietly in their positions —though some of them are seen crawling over the vegetation after it has been shaken from the net; second, their shape and color resembles that of the plants on which they live; and third, they frequently feign death. The writer believes that the instinct of death-feigning is of much importance in the ecology of the animal. It is a form of response which is certainly often highly protective. Many workers have frequently observed the death-feigning reaction among insects and to some extent the rôle which it plays in their lives. Among these observers may be mentioned the names of DeGeer, Fabre, Darwin (1884), Romanes (1884), and Whitman (1899). More recently papers by Holmes (1906) and Severin and Severin (1911a) have been written. Both of these deal with the death-feigning responses from a careful experimental point of view and are extremely valuable pieces of research. That the larvæ, nymphs, and imagoes of many aquatic insects evidence this interesting form of behavior is well brought out by these workers. This is especially the case in the paper by Severin and Severin (1911a, p. 36).

Agrionid nymphs are found in quiet waters at a depth varying from 10–80 cm. deep. So they live in an environment where the light is dim, a sort of twilight, certainly not a bright light. Then frequently there are reeds, sedges, cat-tails, pond-lilies, arrowheads, and other aquatic plants which form shadows, so modifying the action of the sun's rays. It is not at all uncommon to find willows and alders shading the pools which serve as the living places for dragon-fly nymphs. The "selection" of such a habitat is influenced, to a considerable extent, by the natural responses of the animals. They react negatively to bright light and respond positively to contact. The laboratory experiments largely bear out these environmental observations.

ENEMIES.

Before considering the reactions of Agrionid nymphs to photic stimuli, it seems worth while to discuss briefly their food and enemies. While no extensive notes were taken on either of these subjects, yet some observations were recorded which indicate that the facts discussed in the last three paragraphs have a more or less direct bearing upon the relations of the nymphs to their food and enemies. In the states of Michigan and Minnesota, the two gamy little fishes, the common sun-fish, *Lepomis gibbosus*, and the yellow perch, *Perca flavescens*, are very abundant. Both of these species have frequently been taken by the writer in considerably numbers. It was often noticed that among other insects, found in the digestive tract, Odonate nymphs were present and many of them were Agrionid nymphs. It is very likely that Agrionid nymphs form a large portion of the diet of many other species of fish. In fact, Forbes (1888, pp. 485–524) found that the nymphs of Odonata formed a very important article of food in the case of the following fish: the common perch, *Perca flavescens*, the pirate perch, *Aphredoderus sayanus*, the crappie, *Pomoxis annularis*, and the grass pickerel, *Esox vermiculatus*. In the case of each of the three first named fishes, it was found that dragon-fly nymphs formed 10–13 per cent. of their food; and in the case of the grass pickerel, they formed 25 per cent. of the food. Needham (1898, p. 86) states that he has seen dragon-fly nymphs taken in numbers from the stomachs of the Great Blue and Green Herons. Aaron (Lamborn, 1890, p. 50)

states that *Ranatra*, *Notonecta*, and *Belostoma* all prey upon the young nymphs of dragon-flies. From the context, one infers that Aaron's statement is based upon out-of-door observations.

Incidental observations were made upon the enemies of the dragon-fly nymphs when kept in confinement. In one aquarium, there were a number of the Agrionid nymphs and three Belostomas. In another aquarium, there were several of the nymphs and one *Ranatra*. It was found that both of these aquatic bugs preyed on the dragon-fly nymphs. At least three definite records were obtained with reference to *Belostoma* and two with reference to *Ranatra*. The nymph is seized by means of the first pair of legs—in the case of both *Belostoma* and *Ranatra*—and after the bug has placed its prey in a convenient positon, the "bill-like" mouth parts are pushed into the softer portions of the body, and the juices sucked out. Bueno (1903, p. 235) gives a good description of the method used by *Ranatra* in catching its prey. The behavior of *Belostoma*, when engaged in obtaining food is interestingly described by Severin and Severin (1911, pp. 101–102). Other naturalists have observed that many insects are enemies of dragon-fly nymphs while in confinement. Severin and Severin (1911, pp. 102–104) state that *Belostoma* and *Nepa* are both enemies of dragon-fly nymphs and prey upon them. Weed (1889, pp. 11–12) has noticed that in his aquaria the most important element of food of *Belostoma*, consisted of the nymphs of the larger dragon-flies.

FOOD.

The Agrionid nymphs are largely predaceous in their manner of feeding. They feed upon small Crustaceans and the nymphs of certain other small forms, particularly upon the nymphs of May-flies. It is a task of considerable difficulty and one requiring much patience to observe these organisms feeding in their natural habitat. The writer has observed, that in captivity, they feed upon each other, especially is this true, when the food supply is not abundant. Three dozen specimens were placed in an aquarium jar, no food being added, and at the end of three months there were two nymphs alive in the jar. One can readily see the nymph in the very act of seizing its food, in an aquarium jar. The prey is seized by the lobes of the labium, this organ being thrust forward with great rapidity. The

Agrionid nymphs usually remain obscured among the vegetation, where they seize the prey which approaches them. However, the writer has frequently observed them to move a distance of 30 or 40 mm. toward their prey. The general movements remind one very much of those of a cat stealing upon a bird. The body crouches low, almost touching the substratum. The animal moves forward slowly, with bent legs, until it is close to its victim, then the lower lip is suddenly darted forward and the prey is captured. They will also feed upon freshly killed *Physa*, and small pieces of fresh beef.

Needham and Hart (1901, p. 17) make the following statement regarding the food of dragon-fly nymphs. "The nymphs are all predatory in habit. Most species remain in ambush, aided by coverings of sand, mud, silt, and algal growths, and by their own protective coloring, until their prey wanders within reach. *Anax junius* and a few others choose their prey. All capture it with a marvellously sudden extension of the labium, bringing it into the grasp of the formidable lateral lobes. Almost all kinds of small aquatic animals appear on the bill of fare of the group as a whole. The *Agrionidæ* have a seeming preference for *Entomostraca* and May-fly nymphs. The vegetation-inhabiting species have the most varied diet, including especially back-swimmers (*Notonecta*) and water-boatmen (*Corisa*), small crustaceans, such as *Asellus* and *Allorchestes*, thin-shelled mollusks, like *Physa*, coleopterous and dipterous larvæ, and even the younger or weaker members of their own order. *Anax* takes even the thicker-shelled univalves, like *Amnicola*. The deep-water *Epicordulia* feeds principally on small mollusks, such as *Amnicola* and *Physa*, as well as on other life of the bottom. The *Aeschnidæ*, especially *Anax*, are most omnivorous creatures. The larger odonate nymphs eat very young fish, and in some cases appear to have caused a sweeping destruction of large numbers of them."

RESPONSE TO INTENSE ARTIFICIAL LIGHT.

There is a considerable amount of literature treating upon the photic responses of insects. The papers of Loeb (1905) are perhaps the most widely quoted. These have recently been translated and published. Little work has been done on the reactions of dragon-fly nymphs to light and contact. Plateau (1888) experimented with dragon-flies, but his observations are

from a different viewpoint—"visual perception of movement"—than that presented in the present paper. Further, Plateau's work was done with the imagoes and not with the nymphs. Some research has been carried on by Sondheim (1901) in connection with damsel-fly nymphs, regarding the power of associating certain appearances with food. Radl (1903) is the only author, of which the writer is aware, who has published any observations of this nature upon dragon-fly nymphs. Attention should also be called to the very interesting work of von Uexküll. One of his investigations in a series of Studies on Tonus was on the dragon-fly (1908).

Agrionid nymphs react strongly to the light from the electric arc of a Thomson projection lantern, swimming away from the source of illumination. Experiments were performed with separate individuals and also with a number of nymphs in the glass trough at the same time. After placing the vessel, containing the specimens, in the beam of light entering the dark room, it is seen that they swim away rapidly from the light to the far end of the dish—to the end farthest from the source of illumination. If the position of the trough is now reversed—the far end being placed in such a position that it is in the beam of light and facing its source—the creatures again swim away from the light. This experiment was repeated many times. Fresh nymphs were used from time to time.* At each experiment the animals swim away from the source of light and tend to congregate at the end of the glass trough most distant from the lantern.

MOVEMENT AWAY FROM THE LIGHT NOT A RESPONSE TO TEMPERATURE.

An observer of my experiments, who was at the time engaged upon some temperature studies of hydra, believed that the reactions described were responses to heat. That such was not the case was readily demonstated. A cell containing distilled water was placed in front of the projection lantern. The animals respond to the light in the manner previously stated and swim to the far end of the glass trough. A second cell was placed immediately in front of the first, so that the beam of

*The specimens were taken from aquaria standing in a moderate light at some distance from a south window. Such nymphs had not been subjected to the kind of stimuli used in the experiments. Of course, this does not mean that no stimuli had been acting upon them, for stimuli constantly impinge upon all animals.

light now passed through a wall of water approximately 15 cm. in thickness. My records show that, in a period of 30 minutes, the increase in temperature is very small. The dragon-fly nymphs react negatively to the light, as they did before either of the two cells were placed in position. This shows their movement to be a response to light, and not a reaction to temperature.

RESPONSE TO CONTACT.

When experiments are performed with a number of individuals in the glass trough, it is found that their movements are often very much modified. As they swim away from the source of illumination, they frequently come in contact with the sides of the vessel and with other individuals. This contact, in many instances, impedes the movement away from the light, and causes the nymphs to become practically motionless. This is the result of the contact stimulus. They usually assume a position with the long axes of their bodies parallel to each other and in close contact, although this relation may be modified considerably. Another response, which the writer designates as the "clasping response," quickly follows. The nymphs clasp each other closely around the thorax and abdomen. The preliminary contact of their bodies causes locomotion to cease, being an example of true thigmotaxis. Then as the full surface of the body of one is applied to the body of another the "clasping response" results.

FORMATION OF GROUPS.

The reactions above described often result in the formation of groups of nymphs. In this manner one large cluster may be formed, or a number of smaller ones. These collections may be formed at various points in the glass trough, but seldom at the end next to the source of light. They frequently form first at the end of the vessel farthest from the source of illumination. They may, however, form at other points nearer the light. As many as forty and fifty individuals, clinging together, are not infrequently counted in one cluster. The origin and permanence of the groups are due to the contact and clasping reactions. As various individuals swim away from the light, they may come in contact with other individuals, thus eliciting the thigmotactic response. Locomotion ceases and, as a greater bodily surface is applied in the case of the various nymphs, the "clasping response" is invoked, causing the creatures to hold each other tightly by means of their thoracic appendages.

INHIBITION OF PHOTIC RESPONSE.

It is evident from the above observations that the reactions to light may be largely overcome by the response to contact. The efforts of the nymphs to swim away from the light are inhibited by thigmotaxis. The thigmotactic tendencies are evidenced by the organisms forming rather closely grouped aggregations. Various authors have called attention to somewhat similar facts. Formerly, comparatively little importance seems to have been attached to such observations, at least, among insects. More recently, however, certain workers have been impressed with phenomena of this nature. Holmes (1905, pp. 324–325) in his experiments with *Ranatra* has observed that, "The phototactic responses of *Ranatra* which usually occur with such regularity and precision are sometimes checked when the insect is engaged in performing some other function. * * * * Efforts to go toward the light are frequently inhibited by contact stimuli. When several individuals are put into a dish of water near a window they commonly cease, after a time, to swim towards the light and form a cluster in which they lie at all possible angles to the direction of the rays." The same writer (1905, p. 320) also describes how Ranatras group themselves into "a dense bunch at the negative end "of the dish. Again, Holmes (1905, p. 323) while working with the same aquatic forms, states that, "In cool water there is a marked tendency to form a dense cluster in the negative end of the dish." Severin and Severin (1911, pp. 100–101) in connection with some work on the thigmotactic responses of *Belostoma flumineum* Say make the following statement: "Again, it was not unusual to find two or more Belostomas or somewhat larger clusters clinging together at the surface or bottom of the water, a characteristic which is also noticed with *Lethocerus* (=*Belostoma Aucct.*) *americanum*, *Benacus griseus*, *Nepa apiculata*, *Ranatra americana*, and *Ranatra kirkaldyi*. This habit is probably a manisfestation of their thigmotactic response." This tendency to cluster together has frequently been observed by the writer in the case of *Gerris remigis* Say.

CHANGES OF BODILY CONDITIONS.

Much very valuable work has been done upon changes of bodily condition, especially among the Protozoa, as for example the researches of Putter (1900), Moore (1903), and particularly

Jennings (1906, pp. 92–102). The following interesting quotation (pp. 92–94) is taken from the latter's observations upon Paramecia: "If the animal is at rest against a mass of vegetable matter or a bit of paper under the action of contact stimulus and it is then struck with the tip of a glass rod, we find that at first it may not react to the latter stimulus at all. * * * * Finally a strong blow on the anterior end causes the animal to leave the solid and give the typical avoiding reaction. * * * * If specimens showing the contact reaction are heated, it is found that they do not react to the heat until a higher temperature is reached than that necessary to cause a definite reaction in free-swimming specimens. * * * * On the other hand, both heat and cold interfere with the contact reaction. Paramecia much above or below the usual temperature do not settle against solids with which they come in contact, but respond instead by a pronounced avoiding reaction. * * * * Specimens in contact with a solid react less readily to chemicals than do free specimens. * * * * On the other hand, immersion in strong chemicals prevents the positive contact reaction * * * *. The contact reaction may completely prevent the reaction to gravity."

The inhibition of one stimulus by another is a somewhat puzzling matter. Why should a dragon-fly nymph reacting negatively to light, as it comes in contact with another nymph, cease this function and display its thigmotactic proclivities? The stimulus from the electric arc of a projection lantern is so strong that we might expect the organism to continue to react to the light rather than to respond to contact. However, this is not the case for the stimuli are sufficiently powerful to overcome the response to light. The explanation seems to lie with certain changes which take place within the animal. The external conditions are the same—the stimuli from the electric arc are still present—but the nymphs no longer react; the organisms now respond to contact stimuli. (However, some of the nymphs continue to react to the light.) One form of response gives way to another. This is probably due to certain changes in the bodily state of the organisms. We are unable to witness these changes as they occur within the animals themselves, but they can be inferred from the difference in the external response. Jennings (1904, p. 120), in connection with his discussion of the reactions of Stentors, has stated that, "We

must conclude then that contact with solids so alters the physiological condition of the organisms that they no longer react to the other stimuli." This change in the internal condition of dragon-fly nymphs must take place very rapidly, for as soon as an organism—that is swimming along under the influence of photic stimuli from the projection lantern—comes in contact with other nymphs, locomotion stops, and the animal responds to contact stimuli. If the electric arc should be turned off—thus doing away with photic stimuli—it would not be surprising to see the nymphs react in a different manner. Such a change is undoubtedly physiological, and must be largely explained by the new external stimuli acting upon the organism. Moreover, it may be possible that the stimuli from the electric arc have so modified the animal's internal condition that it responds to contact stimuli more readily than if it had not previously been subjected to photic influence. As Jennings (1906, p. 96) has well brought out in his work upon Paramecia, "The essential factor in the interference is a physiological one. When reacting to the contact stimulus, the animal is less easily affected by other stimuli, and when reacting to the other stimuli, it is less easily affected by the contact stimulus. Since the two stimuli in question require behavior of opposite character, it is indeed inevitable that one should give way to the other, or at least modify the behavior toward it; both cannot receive the usual reaction." Mast (1911, p. 287) in his discussion of "the effect of internal changes" makes the following interesting statement: "As a matter of fact, all reactions are directly controlled by internal forces which are in turn influenced by external factors." Jennings (1904, pp. 109–127) and (1906, pp. 283–313) has written full and elaborate discussions concerning "physiological states." Both of which are extremely interesting and suggestive.

DISINTEGRATION OF GROUPS.

Holmes (1905, p. 308) has found that Ranatras form a cluster in an aquarium. "In this way they may lie for hours in an almost motionless state." While somewhat similar conditions may be observed in the case of dragon-fly nymphs, the periods of quiet are very much shorter and the disintegration of the groups occurs from time to time. This is brought about by mechanical—contact—stimuli and response to the

strong electric light. At irregular intervals the nymphs in the cluster make "spontaneous" movements—or at least movements that are often difficult to interpret from any external cause, though some of them may be due to the continued action of the electric arc—and such movements act as mechanical—contact—stimuli on other members of the group. This naturally tends to cause the animals to change their relative positions to some extent; and no matter how slight a change in position this may be, there is, for a short space of time, a slackening of the grip of the appendages. At such moments an opportunity is presented for photic stimuli to act upon the nymphs, and they frequently break away from the aggregation, responding with the negative reaction to light. This is more readily understood if we realize that the organisms are probably in a different physiological state than they were when the group was first formed—a state which now results in a response to the photic stimuli, and not to thigmotactic stimuli. The "spontaneous" or other slight movements of the animals in the closely packed masses are of great importance in initiating the breaking up of the clusters. Holmes (1095, p. 323) has observed in his experiments with *Ranatra* that the groups are more apt to be broken up as the insects become more active. The dragon-fly nymphs in the peripheral portion of the clusters are more likely to swim away first, while those in the central part are the last to leave the collections, as it is more difficult for the electric light to affect them in such a position. They are largely shut off from the light because of the nymphs surrounding them, besides being more largely influenced by contact stimuli. Holmes (1905, p. 308) states that in these clusters formed by *Ranatra*, the insects "are often so closely aggregated and so tangled together that those which are near the center of the group experience much difficulty in disengaging themselves."

We have noticed that dragon-fly nymphs respond negatively to photic stimuli. It has also been shown that they are positively thigmotactic. Their negative response to light often brings them against the sides of the experimentation dish and against each other. This contact invokes thigmotaxis, and the animals become grouped together. Mechanical—contact—stimuli plus the influence of the strong electric light inhibits the contact reactions for the time being, and the aggregation is broken up, the organisms swimming away from each other in response to

their phototactic proclivities. Later on the nymphs may again form a group which in turn will be dispersed. Observations very similar to these have been recorded by Holmes (1901, p. 212) upon *Gammarus locusta*. When these Crustaceans are exposed to light, they swim away from the *Ceratophyllum*, in the dish of water, to which they were clinging. They move rapidly to the negative end of the vessel, where they dart actively about, as if attempting to get farther away from the light. If these movements bring the animals in contact with the *Ceratophyllum* again, there they remain. If there are no objects in the water, the contact response is not invoked, and the organisms are found at the negative end of the dish. If there are objects in the water, the Amphiopods react to contact stimuli whenever their chance movements bring them against a solid surface. The creatures remain in such a position until the phototactic impulse again causes them to swim away.

INDEFINITENESS AND CHANGE OF PHOTIC RESPONSE.

Sometimes, immediately following the breaking up of the aggregation of dragon-fly nymphs, the movements of the animals appear to lack definiteness. They swim away from the groups at various angles to the rays of light. While most of them sooner or later move toward the negative end of the glass trough, there are some whose reactions are indifferent, and a few evidence a tendency to positiveness in their responses to the light. This again the writer attributes to a change in the internal condition of the creatures, induced perhaps either by thigmotaxis or by the effect of the light from the projection lantern. Holmes (1905, pp. 318–325) has performed some very interesting experiments with *Ranatra* along similar lines. The insect is usually strongly positive in its responses to light; but this worker has been able to cause the animal to become negatively phototactic through the agency of contact stimuli. This change in the photic response, he was able to bring about many times. On one occasion the Ranatras were exposed to the light from a window for more than an hour and half, and it was found at the end of that time that all the specimens had become negatively phototactic. Previously they had all reacted positively to the light, yet they had become negative in their reactions although the intensity of the light had increased. He has also demonstrated that the negative phototaxis of these

animals may be held in check by contact stimuli, as stated in the following quotation (1905, p. 325): "Contact stimuli not only inhibit positive phototaxis, but they produce a negative reaction as we have already seen; the latter tendency, however, is often held in check by the same cause by which it is brought about."

RESPONSE TO LESS INTENSE ARTIFICIAL LIGHT.

My experiments on dragon-fly nymphs with a 16 c. p. incandescent light show that the animals respond negatively, their movements taking them to the end of the glass trough farthest from the source of illumination. Frequently the organisms walk from one end of the vessel to the other in a rather leisurely fashion. In such cases the swimming mode of locomotion seems to be inhibited. The reactions are often lacking in promptness and precision as the following experiments will show:

Experiment A. The nymph is placed, by means of a camel's hair brush, in the glass trough facing the light. The creature is slightly nearer to the left than it is to the right side of the vessel. Immediately the animal turns slowly half way around. This movement is slow. Now, the anterior pair of legs come in contact with the side of the dish. It walks entirely onto the side of the trough. At the same time it continues the turning movement, until the head points away from the light. It walks slowly along the side for half the length of the vessel. The nymph stops for 5 seconds. Again it moves forward until within 4 cm. of the end of the trough. It stops and performs cleaning reactions. In a few seconds, the animal walks slowly to the end of the trough.

Experiment B. The nymph is placed in the center of the glass dish, at the end near the source of light. It remains stationary for 7 seconds. The animal then turns slowly to the right until in a position oblique to the direction of the rays. It again remains quiet for 3 seconds. It turns slowly further to the right and at the same time moves slightly toward the right side of the vessel. The front legs come in contact with the glass side and the nymph stops for 4 seconds. The creature turns very slowly until it is in a position at right angles to the rays of light. As it turns, it walks slowly up the side of the dish. It remains here for 5 seconds in a position perpendicular to the floor of the trough. The animal turns slowly, the long axis of its body becoming parallel with the rays of light. It moves away from the light for a distance of 5 cm. It then stops for 2 seconds. It again moves forward for a distance of 5 cm. The nymph now stops for 3 seconds. It moves forward slowly for 2 cm. It stops for 2 seconds and then goes ahead a distance of 4 cm. The creature remains quiet for 3 seconds, after which it walks forward for 1 cm. It again stops; this time for a period of 16 seconds and performs cleaning reactions. It then moves slowly to the end of

the dish, passing the concave corner, and comes to rest at the end of the trough at right angles to the rays of light.

Experiment C. The nymph is placed in the glass dish at the end toward the light. It turns slowly toward the left until the body is at right angles to the rays of light. It remains in this position for 2 seconds. The animal turns further to the left. Its body is now oblique to the rays of light. It moves obliquely forward 1 cm. The nymph turns to the left so that its body is now parallel with the rays of light. It swims forward 8 cm. and then stops, resting on the bottom of the vessel. It remains stationary 6 seconds. Then it walks forward 4 cm. It stops for 3 seconds with its body slightly oblique to the light rays. The animal walks forward 6 cm. and then comes in contact with the side of the dish. It remains in a resting position for 25 seconds. It walks along the side of the vessel for 4 cm. and then reaches the water. It walks forward for 2 cm. and then stops, performing cleaning reactions. After remaining quiet for 20 seconds, it swims to the end of the dish.

The responses of the nymphs as indicated in these experiments are suggestive of those described by Holmes (1902, p. 212) for *Gammarus* and *Amphithöe*. This observer states that, "If a single individual be watched it will be seen to struggle for a time, to move away from the light; it will then rest, for a longer or shorter period, only to resume its struggle later." The writer performed a large number of experiments similar to those described as A, B, and C. In each case different nymphs were used. It is evident that such photic responses are conspicuously lacking in the factors of directness and precision. While the three experiments described are more or less similar in details, it is obvious that there are differences. The nymphs appear to possess some individuality. The movements are not so stereotyped, but that they allow of considerable modification.

A number of experiments were performed in which the same nymph was exposed to the light from the incandescent lamp. Usually there were ten trials in a series, and the same individual was used throughout each series. In referring to the details of my experiments, they indicate, in a general way at least, that in the first few trials of the series, the reactions to light were fairly definite—the animal moving away from the source of illumination. The animals frequently responded by the swimming movement. Toward the end of the series, there were more pauses as the organisms traveled from one end of the dish to the other. The cleaning reactions were performed from time to time as the nymph rested, and walking was the principal method of locomotion.

RESPONSES TO DAYLIGHT.

Daylight was used as the source of stimulation for a large series of experiments. Many observations were recorded upon a great many different dragon-fly nymphs. In general it may be said that there was no evidence of orientation to the direction of the rays, and there seemed to be little indication of response to the light intensity, and the light was certainly brighter at the opening into the dark room than it was some distance away, within the dark room. The animals seemed to be generally indifferent to the light. At times, a few organisms indicated a tendency toward the positive reaction, but such facts are not uncommon in any experiments with light. Unless the dragon-fly nymphs are nothing more than reflex machines, it is to be expected that there will be some physiological variation in the internal condition of the different individuals even under the effect of the same stimuli. There are usually a few animals which appear to vary in their responses from the majority at any given time.

SUMMARY AND CONCLUSION.

The Agrionid nymphs discussed in this paper were collected in the vicinity of Ann Arbor, Michigan. In their natural habitat they respond strongly to contact. They are frequently found clinging to *Elodea* and *Ceratophyllum*, and are generally in close contact with these plants. They are also found in the angles formed by the various parts of the plants. The nymphs are obscured in such positions because of certain resemblances in color and form between themselves and the plants to which they cling. These factors are probably protective, as is the death-feigning instinct which is so well developed in these insects. In the vicinity of Ann Arbor, Michigan, Agrionid nymphs were taken in abundance in still waters, at varying depths from 10—80 cm. They are not generally found in bright light, but are more abundant in habitats shaded by aquatic vegetation and trees. The fact that they inhabit such situations is probably due to their negative response to strong light and to their positive response to contact. Two common enemies of these dragon-fly nymphs are the two species of fishes *Lepomis gibbosus* and *Perca flavescens*. The aquatic bugs *Ranatra* and *Belostoma* destroy large numbers of nymphs, when kept in confinement. Agrionid nymphs are

predaceous insects. They feed upon small Crustaceans and the nymphs of May-flies. When kept in the aquarium, they prey upon each other. They also feed readily upon freshly killed *Physa* and small pieces of fresh beef. The nymphs usually wait for their prey to approach them before seizing it, but they may move a distance of 30—40 mm. toward it. The food is seized by the lobes of the labium as this organ is suddenly darted toward the prey.

Agrionid nymphs respond negatively to the light from a Thompson projection lantern. They swim away from the source of illumination. This occurs both in the case of single individuals and also when a number of specimens are in a glass trough at the same time. If the position of the trough is reversed, the nymphs again swim away from the light. This sort of response continues even when the experiment is repeated a number of times. The movement away from the light is a photic response, and not a reaction to temperature. Frequently, when a number of specimens are placed in the glass trough, the response to light is modified by contact with the sides of the dish and with other individuals. This contact causes the nymphs to become more or less motionless, and to remain in close contact with each other, with their bodies more or less parallel. Such responses are examples of their thigmotactic proclivities. They also exhibit a "clasping response," seizing each other around the thorax and abdomen by means of their thoracic appendages. The thigmotactic and "clasping responses" result in the grouping of the nymphs in clusters. These groups tend to form at the end of the trough farthest from the source of light, although they also occur at other points. Sometimes there are as many as fifty individuals in a group. The origin and permanence of the groups are due to the contact and "clasping responses." The response of Agrionid nymphs to photic stimuli may be overcome by the response to contact stimuli; there is an inhibition of the one by the other. The explanation of this phenomenon seems to rest in part at least, with certain changes—bodily conditions—which take place within the animal concerned. In many instances such changes probably occur rapidly. The clusters of nymphs break up from time to time. The disintegration seems to be due to several causes. The "spontaneous" movements of the insects in the groups are a factor in this. Such

mechanical—contact—stimuli bring about changes in the relative positions of some of the individuals in the various groups. At such times there is a slackening of the grip of the appendages, so permitting photic stimuli to be more effective. The disintegration of the groups, then, is due to mechanical—contact—stimuli plus the stimuli of the powerful electric light. Immediately after the disintegration of a group, there appears to be a lack of definiteness in the responses of the nymphs to the electric light. They swim away from the cluster at various angles to the rays of light. While the majority of them eventually arrive at the end of the trough farthest from the source of light, certain individuals exhibit a tendency to positiveness in their photic responses. This result may be due to a change in bodily condition, induced, possibly, either by thigmotaxis or by the effect of photic stimuli. Agrionid nymphs respond negatively to a 16 c. p. incandescent light, swimming away to the end of the trough farthest from the source of illumination. When responding to such photic stimuli, the insects frequently walk from one end of the trough to the other. The swimming reaction appears to be inhibited. The responses often lack promptness and precision. When the same individual is used in a series of experiments, the responses in the first few trials prove to be fairly definite, the animal swimming away from the source of illumination. Toward the end of the series there are pauses as the animal moves from one end of the trough to the other, and cleaning reactions are performed. When diffuse daylight is used as a source of illumination, the nymphs exhibit practically no response either to light intensity, or to the direction of the rays. A large majority of the insects appear indifferent to the light. A few individuals tend to exhibit a positive response to photic stimuli of this nature.

It seems possible to the writer that the behavior of Agrionid nymphs with respect to light and contact, may not be entirely of a reflex, mechanical nature. Such reactions are not always precise and definite; sometimes they are considerably modified. May they not, as Holmes (1905, pp. 337–349) has shown with respect to *Ranatra*, possess some of the concomitants of the "pleasure-pain" type of reaction? This form of response has been excellently discussed by Holmes (1910), (1911), and (1911a), in several suggestive papers. The thigmotactic and photic reactions of these dragon-fly nymphs appear to be bene-

ficial. Such responses not only aid in concealment from enemies, but also assist in obtaining food. Beneficial reactions are frequently "pleasureable"; at least they are not usually "painful". On the other hand injurious responses are often "painful"; certainly they are not "pleasant". The nymphs are guided fairly well if they follow their "likes" and "dislikes", if such terms may be used. Spencer (1885) has maintained, and Holmes (1910) and (1911a) has discussed the probability that the connection between "pleasure" and "pain" has arisen through natural selection. If this should prove to be true with respect to other animal groups, there seems no reason why it should not apply to Agrionid nymphs.

BIBLIOGRAPHY.

Aaron, C. B. 1890. The Dipterous Enemies of Man, pp. 23–68. New York. (An essay in Lamborn, R. H., Dragon-Flies vs. Mosquitoes.)

Bueno, J. R. de la Torre. 1903. Notes on the Stridulation and Habits of Ranatra fusca Pal. B. Canadian Entomologist, Vol. XXXV, pp. 235–237.

Darwin, C. 1884. A Posthumous Essay on Instinct, pp. 353–384. New York. (Appendix in Romanes, G. J. Mental Evolution in Animals.)

De Geer, C. 1752–1778. Memoires pour servir à l'Histoire des Insectes. I–VII.

Fabre, J. H. 1879–1906? (Sixième-dixième série sans date.) Souvenirs Entomologiques Études sur l'Instinct et les Moeurs des Insectes. 1re–10e. Série. Paris.

Forbes, S. A. 1888. On the Food Relations of Fresh-Water Fishes: A Summary and Discussion. Bulletin Illinois State Laboratory Natural History, Vol. II, Art. VIII, pp. 475–538.

Holmes, S. J. 1901. Phototaxis in the Amphipoda. American Journal of Physiology, Vol. V, No. IV, pp. 211–234.

1905. The Reactions of Ranatra to Light. Journal of Comparative Neurology and Psychology, Vol. XV, No. 4, pp. 305–349.

1906. Death-Feigning in Ranatra. Journal of Comparative Neurology and Psychology. Vol. XVI, No. 3, pp. 200–216.

1910. Pleasure, Pain and the Beginnings of Intelligence. Journal of Comparative Neurology and Psychology, Vol. XX, No. 2, pp. 145–164.

1911. The Beginnings of Intelligence. Science, New Series, Vol. XXXIII, No. 848, pp. 473–480.

1911a. The Evolution of Animal Intelligence. 296, pp. New York.

Jennings, H. S. 1904. Contributions to the Study of the Behavior of Lower Organisms: Carnegie Institution of Washington, Publication 16. 256 pp. Washington.

1906. Behavior of the Lower Organisms. 366 pp. New York.

Loeb, J. 1905. Studies in General Physiology. Part I, 423 pp. Chicago.

Mast, S. O. 1911. Light and the Behavior of Organisms. 410 pp. New York.

Moore, A. 1903. Some Facts Concerning the Geotropic Gatherings of Paramecia. American Journal of Physiology. Vol. 9, pp. 238–244.

Needham, J. G. 1898. Birds vs. Dragon-flies. The Osprey, Vol. II, pp. 85–86.

Needham, J. G. and Hart, C. A. 1901. The Dragon-Flies (Odonata) of Illinois, Part 1. Petaluridæ, Aeschnidæ, and Gomphidæ. Bulletin Illinois State Laboratory of Natural History, Vol. VI, Art. 1, pp. 1–94.

Pearl, R. 1903. The Movements and Reactions of Fresh-Water Planarians. A Study in Animal Behavior. Quarterly Journal of Microscopical Science, Vol. 46, pp. 509–714.

Plateau, F. 1888. Recherches expérimentales sur la vision chez les Arthropodes (cinquième partie). Bulletins de L'Académie Royale des Sciences, des Letteres et des Beaux-Arts de Belgique, cinquante-huitième année, 3me Serie, t. 16, pp. 395–457.

Putter, A. 1900. Studien über Thigmotaxis bei Protistein. Archiv für Anatomie and Physiologie, Physiologische Abteilung, Supplementband 1900, pp. 243–302.

Radl, E. 1903. Untersuchungen über den Phototropismus der Tiere. 188 pp. Leipzig.

Romanes, J. G. 1884. Mental Evolution in Animals. 411 pp. New York.

Severin, H. H. P., and Severin, H. C. 1911. Habits of Belostoma (=Zaitha) flumineum Say and Nepa apiculata Uhler, with Observations on other Closely Related Aquatic Hemiptera. Journal of the New York Entomological Society, Vol. XIX, No. 2, pp. 99–108.

1911a. An experimental Study of the Death-Feigning of Belostoma (=Zaitha Aucct.) flumineum Say and Nepa apiculata Uhler. Behavior Monographs, Vol. 1, No. 3, Serial No. 3, pp. 47. Cambridge.

Sondheim, M. 1901. Wahrnehmungsvermogen einer Libellenlarve. Biologisches Centralblatt, Bd. XXI, Nr. 1, pp. 317–319.

Spencer, H. 1885. Principles of Psychology. 2d ed. Vol. I, 642 pp. New York.

Uexkull, J. V. 1908. Studien uber den Tonus. V. Die Libellen. Zeitschrift für Biologie, Bd. L, pp. 168–202.

Weed, C. M. 1889. Studies in Pond Life. Bulletin Ohio Agricultural Experiment Station. Technical Series, Vol. I, No. 1, Art. II, pp. 4–17.

Whitman, C. O. 1889. Animal Behavior. Biological Lectures from the Marine Biological Laboratory. Wood's Holl, 1898, pp. 285–343. Boston.

Ecological Laboratory, University of Illinois, January 6, 1912.